

## ICESat-2 Virtual File System Orbits

In this *third* vignette I'll make use of the [GDAL Virtual File Systems](#) to download *nominal* and *time specific* orbit data (from the [ICESat-2 Technical Specs website](#)) for an Area of Interest (AOI). This will allow me to reduce the download and computation time once I make the requests to the OpenAltimetry API.

The area of interest is the **Himalayas mountain range** which has some of the *highest peaks* in the world, including *mount Everest*. The following map shows the bounding box area that I'll use in this vignette,

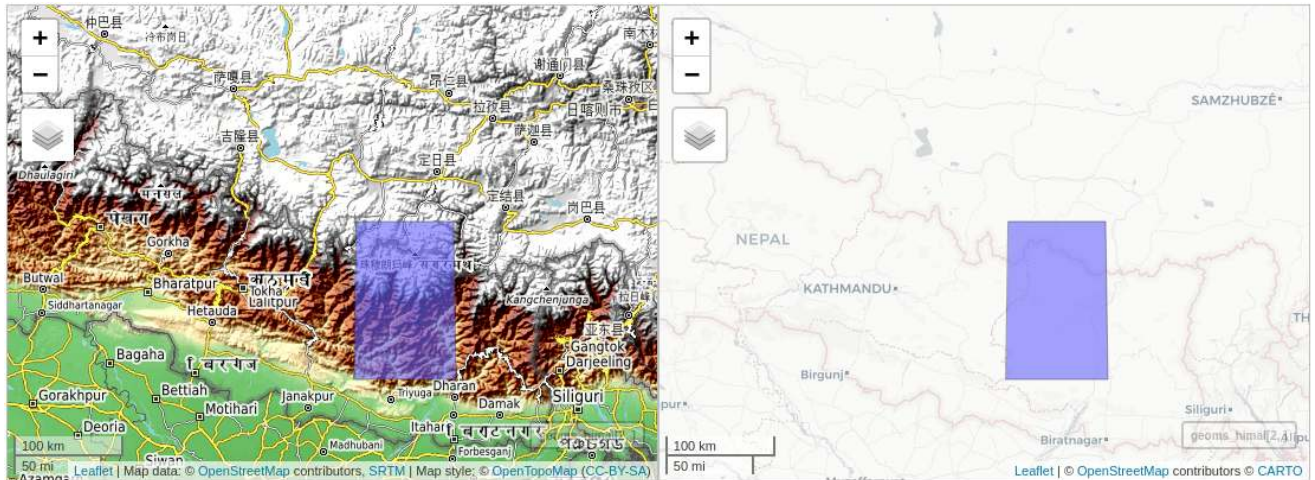


Figure 1: Area of Interest

First, we load the data,

```
pkgs = c('IceSat2R', 'magrittr', 'sf', 'mapview', 'leaflet')
load_pkgs = lapply(pkgs, require, character.only = TRUE) # load required R packages

geoms_himal_pth = system.file('data_files', 'vignette_data', 'himalayas.RDS', package = "IceSat2R")
geoms_himal = readRDS(geoms_himal_pth)
geoms_himal

# Simple feature collection with 2 features and 1 field
# Geometry type: POLYGON
# Dimension: XY
# Bounding box: xmin: 86.35254 ymin: 26.95635 xmax: 87.29736 ymax: 28.25842
# CRS: EPSG:4326
#   area_size geometry
# 1 small POLYGON ((86.36902 27.66164...
# 2 big POLYGON ((86.35254 26.95635...
```

Since the *Himalayas mountain range* is located in the *Eastern Hemisphere* we'll pick this as an area when calling the `IceSat2R::vsi_nominal_orbits_wkt()` function. Moreover, we'll iterate over all 8 available repeats for the *Eastern Hemisphere* to retrieve the *Reference Ground Tracks (RGTs)* of the AOI based on the *nominal orbits*,

```

sf_wkt = sf::st_geometry(subset(geoms_himal, area_size == 'big'))

centr_wkt = sf::st_coordinates(sf::st_centroid(sf_wkt))
dat_wkt = sf::st_as_text(sf_wkt)

lst_out = list()

for (iter in 1:8) {          # iterate over all available repeats

  cat(paste0(iter, '.'))

  dat_iter = IceSat2R::vsi_nominal_orbits_wkt(orbit_area = 'eastern_hemisphere',
                                              track = 'GT7',
                                              rgt_repeat = iter,
                                              wkt_filter = dat_wkt,
                                              download_method = 'curl',
                                              download_zip = FALSE,
                                              verbose = TRUE)

  lst_out[[iter]] = dat_iter
}

# 1.The available Icesat-2 orbits will be red from 'https://icesat-2.gsfc.nasa.gov/ ...
# Access the data of the technical specs website ...
# Extract the .zip files and the corresponding titles ...
# Keep the relevant data from the url's and titles ...
# Process the nominal and time specific orbits separately ...
# Adjust the Dates of the time specific orbits ...
# Create the nominal orbits data.table ...
# Create the time specific orbits data.table ...
# Return a single data.table ...
# .....
# 8.The available Icesat-2 orbits will be red from 'https://icesat-2.gsfc.nasa.gov/ ...
# Access the data of the technical specs website ...
# .....
# Elapsed time: 0 hours and 0 minutes and 2 seconds.
# Data based on repeat and track will be kept ...
# Data based on repeat and track will be kept ...
# The file 'EasternHem_repeat8_GT7.kmz' will be processed ...
# Total Elapsed time: 0 hours and 0 minutes and 5 seconds.

lst_out = unlist(lst_out, recursive = F)
unq_rgts = as.vector(unique(unlist(lapply(lst_out, function(x) x$RGT))))
unq_rgts

# [1] "96"   "157"  "363"  "538"  "599"  "805"  "866"  "1041" "1308" "1247"

```

For this specific use case we are interested in ICESat-2 data for a specific time period,

- from ‘2020-01-01’ to ‘2021-01-01’ (1-year’s data)

Therefore, we’ll make use of the `IceSat2R::vsi_time_specific_orbits_wkt()` function which queries all 15 ICESat-2 RGTs cycles (as of March 2022) to come to the RGTs intersection for the specified 1-year time interval,

```

date_start = '2020-01-01'
date_end = '2021-01-01'

orb_cyc_multi = IceSat2R::vsi_time_specific_orbits_wkt(date_from = date_start,
                                                       date_to = date_end,
                                                       RGTs = unq_rgts,
                                                       wkt_filter = dat_wkt,
                                                       verbose = TRUE)

# The available Icesat-2 orbits will be red from 'https://icesat-2.gsfc.nasa.gov/ ...
# Access the data of the technical specs website ...
# Extract the .zip files and the corresponding titles ...
# Keep the relevant data from the url's and titles ...
# Process the nominal and time specific orbits separately ...
# Adjust the Dates of the time specific orbits ...
# Create the nominal orbits data.table ...
# Create the time specific orbits data.table ...
# Return a single data.table ...
# Elapsed time: 0 hours and 0 minutes and 0 seconds.
# In total there are 5 intersected dates for which data will be processed!
# The RGT cycles from which data will be processed are:
#       RGT_cycle_6, RGT_cycle_7, RGT_cycle_8, RGT_cycle_9, RGT_cycle_10
# -----
# RGTs of cycle 'RGT_cycle_6' will be processed ...
# -----
# The 'sf' gdalinfo returned an empty character string! Attempt to read the url using
# the OS configured 'gdalinfo' function ...
# The internal type of the .zip file is 'kml'
# The 'https://icesat-2.gsfc.nasa.gov/sites/default/files/page_files/IS2_RGTs_cycle6_...'
# 'zip' file includes 1387 'kml' files.
# Elapsed time: 0 hours and 0 minutes and 8 seconds.
# 6 out of 10 sublists were empty and will be removed!
# -----
# RGTs of cycle 'RGT_cycle_7' will be processed ...
# -----
# .....
# .....
# -----
# RGTs of cycle 'RGT_cycle_10' will be processed ...
# -----
# The 'sf' gdalinfo returned an empty character string! Attempt to read the url using th ...
# 'gdalinfo' function ...
# The internal type of the .zip file is 'kml'
# The 'https://icesat-2.gsfc.nasa.gov/sites/default/files/page_files/IS2_RGTs_cycle10_date ...
# 'zip' file includes 1387 'kml' files.
# Elapsed time: 0 hours and 0 minutes and 6 seconds.
# 6 out of 10 sublists were empty and will be removed!
# In total 5 RGT cycles will be included in the output 'sf' object (RGT_cycle_6, RGT_cycle_7,
# RGT_cycle_8, RGT_cycle_9, RGT_cycle_10)!
# output of 'RGT_cycle_6' will be re-formatted ...
# The 'description' column of the output data will be processed ...
# output of 'RGT_cycle_7' will be re-formatted ...

```

```

# The 'description' column of the output data will be processed ...
# output of 'RGT_cycle_8' will be re-formatted ...
# The 'description' column of the output data will be processed ...
# output of 'RGT_cycle_9' will be re-formatted ...
# The 'description' column of the output data will be processed ...
# output of 'RGT_cycle_10' will be re-formatted ...
# The 'description' column of the output data will be processed ...
# Total Elapsed time: 0 hours and 2 minutes and 37 seconds.

```

The query returns 18 different Date-Time matches for our defined 1-year time period,

```
orb_cyc_multi
```

```

# Simple feature collection with 18 features and 14 fields
# Geometry type: POINT
# Dimension:      XY
# Bounding box:   xmin: 86.45225 ymin: 27.09347 xmax: 87.22874 ymax: 27.11331
# CRS:            EPSG:4326
# First 10 features:
#   .... drawOrder icon  RGT          Date_time day_of_year cycle          geometry
# 1   ....      NA <NA>   96 2020-01-02 00:37:11         2      6 POINT (86.97015 27.10272)
# 2   ....      NA <NA>  538 2020-01-30 23:13:14        30      6 POINT (87.22874 27.09347)
# 3   ....      NA <NA>  599 2020-02-03 23:04:54        34      6 POINT (86.45225 27.11331)
# 4   ....      NA <NA> 1041 2020-03-03 21:40:57        63      6 POINT (86.71086 27.1045)
# 5   ....      NA <NA>   96 2020-04-01 20:17:02        92      7 POINT (87.09815 27.08729)
# 6   ....      NA <NA>  599 2020-05-04 18:44:45       125      7 POINT (86.58026 27.09789)
# 7   ....      NA <NA> 1041 2020-06-02 17:20:48       154      7 POINT (86.83886 27.08907)
# 8   ....      NA <NA>   96 2020-07-01 15:56:55       183      8 POINT (87.00215 27.09888)
# 9   ....      NA <NA>  538 2020-07-30 14:32:58       212      8 POINT (87.26075 27.08963)
# 10  ....      NA <NA>  599 2020-08-03 14:24:38       216      8 POINT (86.48426 27.10947)

```

We'll use the *mapview* R package to visualize our AOI bounding box with the intersected time-specific RGTs,

```

# make the sf-objects valid
orb_cyc_multi = sf::st_make_valid(orb_cyc_multi)
sf_wkt = sf::st_make_valid(sf_wkt)

# plot the sf-objects
orbit_cy = mapview::mapview(orb_cyc_multi, legend = F)
AOI_wkt = mapview::mapview(sf_wkt, legend = F)

lft = orbit_cy + AOI_wkt

lft = lft@map %>% leaflet::setView(lng = as.numeric(centr_wkt[, 'X']),
                                   lat = as.numeric(centr_wkt[, 'Y']),
                                   zoom = 7)

lft

```

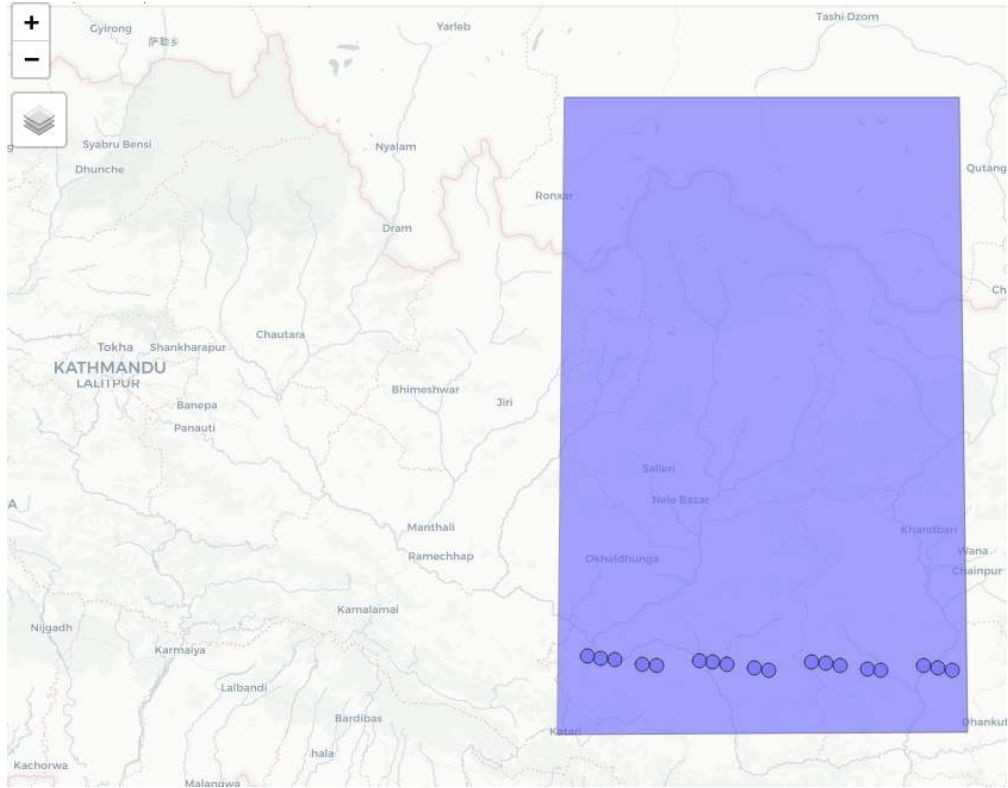


Figure 2: Intersected RGTs

The output of ‘*usi\_time\_specific\_orbits\_wkt()*’ can be verified with the *OpenAltimetry*’s ‘*getTracks()*’ function,

```
bbx_aoi = sf::st_bbox(obj = sf_wkt)

dtbl_rgts = verify_RGTs(nsicd_rgts = orb_cyc_multi,
                        bbx_aoi = bbx_aoi,
                        verbose = TRUE)
```

dtbl\_rgts

#	Date_time	RGT_OpenAlt	RGT_NSIDC
# 1:	2020-01-02	96	96
# 2:	2020-01-30	538	538
# 3:	2020-02-03	599	599
# 4:	2020-03-03	1041	1041
# 5:	2020-04-01	96	96
# 6:	2020-05-04	599	599
# 7:	2020-06-02	1041	1041
# 8:	2020-07-01	96	96
# 9:	2020-07-30	538	538
# 10:	2020-08-03	599	599
# 11:	2020-09-01	1041	1041
# 12:	2020-09-30	96	96
# 13:	2020-11-02	599	599
# 14:	2020-12-01	1041	1041
# 15:	2020-12-30	96	96

# 16: 2021-01-28	538	538
# 17: 2021-02-01	599	599
# 18: 2021-03-02	1041	1041