

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,

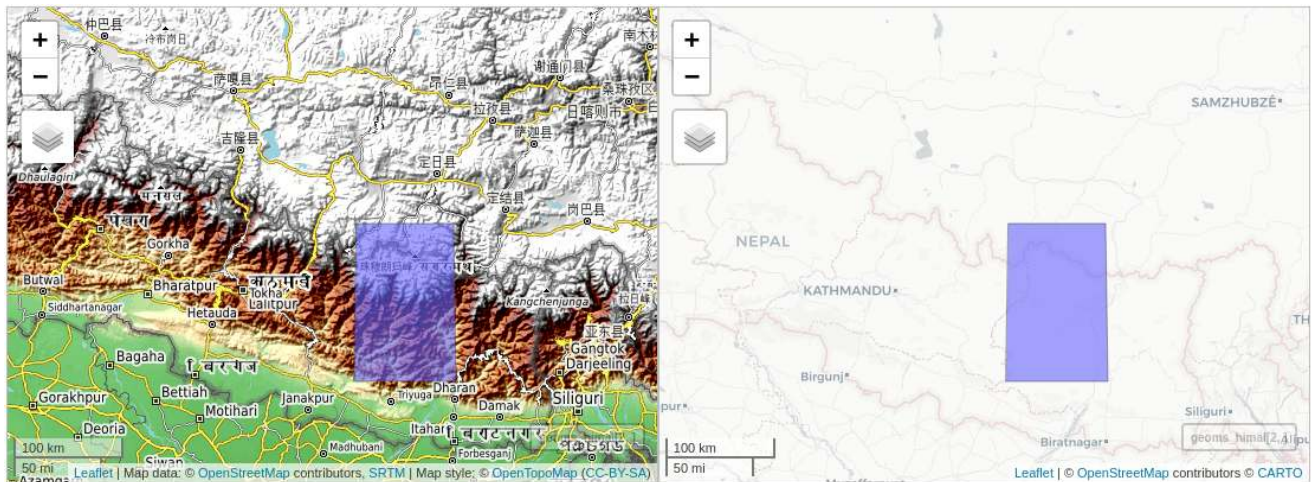


Figure 1: Area of Interest

First, we load the data,

```
require(IceSat2R)
require(magrittr)

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::usi_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,

```
orbit_cy = mapview::mapview(orb_cyc_multi, legend = F)
AOI_wkt = mapview::mapview(sf_wkt, legend = F)

lft = orbit_cy + AOI_wkt

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

The output of *'vsi_time_specific_orbits_wkt()'* can be verified with the *OpenAltimetry's 'getTracks()'* function,

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

rows_match = rep(FALSE, nrow(orb_cyc_multi))

for (row in 1:nrow(orb_cyc_multi)) {

  dat_item = orb_cyc_multi[row, , drop = F]
  Date = as.Date(dat_item$Date_time)

  op_tra = IceSat2R::getTracks(minx = as.numeric(bbx_aoi['xmin']),
                               miny = as.numeric(bbx_aoi['ymin']),
```

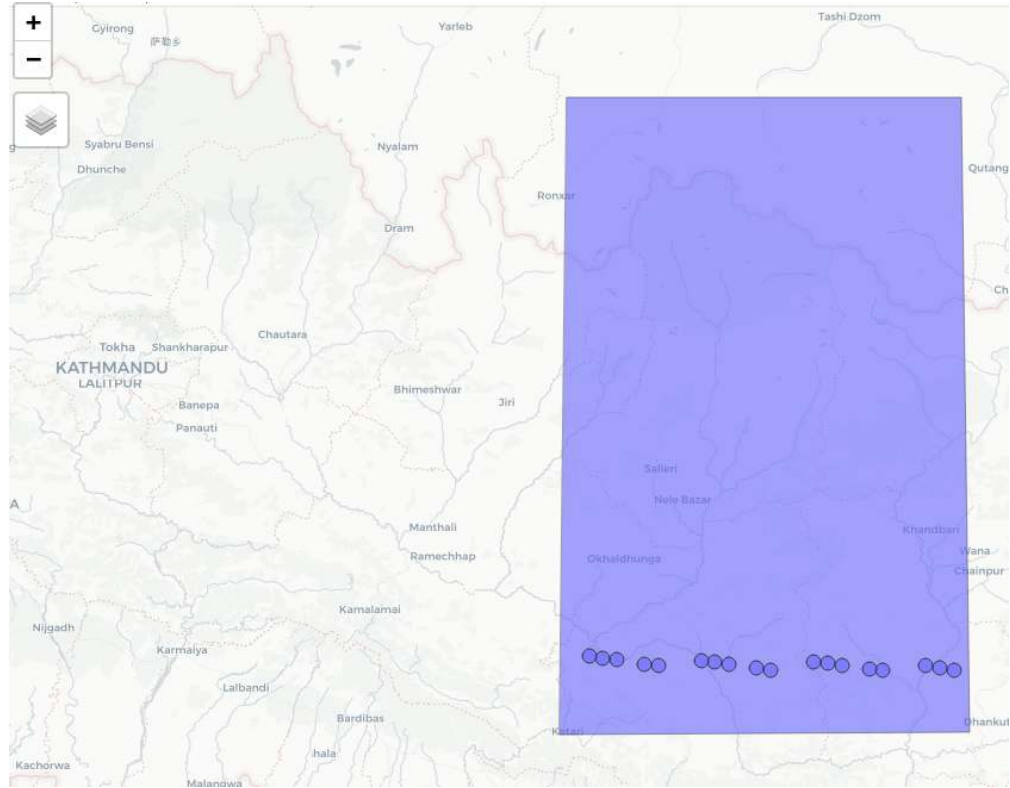


Figure 2: Intersected RGTs

```

maxx = as.numeric(bbx_aoi['xmax']),
maxy = as.numeric(bbx_aoi['ymax']),
date = as.character(Date),
outputFormat = 'csv',
download_method = 'curl',
verbose = FALSE)

date_obj = dat_item$Date_time
tim_rgt = glue::glue("Date: {date_obj} Time specific RGT: '{dat_item$RGT}'")

if (nrow(op_tra) > 0) {
  iter_op_trac = paste(op_tra$track, collapse = ', ')
  cat(glue::glue("{tim_rgt} OpenAltimetry: '{iter_op_trac}'"), '\n')

  if (length(op_tra$track) == 1) {
    if (op_tra$track == dat_item$RGT) {
      rows_match[row] = TRUE
    }
  }
}
else {
  cat(glue::glue("{tim_rgt} without an OpenAltimetry match!"), '\n')
}
}

```

Date: 2020-01-02 00:37:11 Time specific RGT: '96' OpenAltimetry: '96'
Date: 2020-01-30 23:13:14 Time specific RGT: '538' OpenAltimetry: '538'
Date: 2020-02-03 23:04:54 Time specific RGT: '599' OpenAltimetry: '599'
Date: 2020-03-03 21:40:57 Time specific RGT: '1041' OpenAltimetry: '1041'
Date: 2020-04-01 20:17:02 Time specific RGT: '96' OpenAltimetry: '96'
Date: 2020-05-04 18:44:45 Time specific RGT: '599' OpenAltimetry: '599'
Date: 2020-06-02 17:20:48 Time specific RGT: '1041' OpenAltimetry: '1041'
Date: 2020-07-01 15:56:55 Time specific RGT: '96' OpenAltimetry: '96'
Date: 2020-07-30 14:32:58 Time specific RGT: '538' OpenAltimetry: '538'
Date: 2020-08-03 14:24:38 Time specific RGT: '599' OpenAltimetry: '599'
Date: 2020-09-01 13:00:41 Time specific RGT: '1041' OpenAltimetry: '1041'
Date: 2020-09-30 11:36:37 Time specific RGT: '96' OpenAltimetry: '96'
Date: 2020-11-02 10:04:20 Time specific RGT: '599' OpenAltimetry: '599'
Date: 2020-12-01 08:40:23 Time specific RGT: '1041' OpenAltimetry: '1041'
Date: 2020-12-30 07:16:28 Time specific RGT: '96' OpenAltimetry: '96'
Date: 2021-01-28 05:52:31 Time specific RGT: '538' OpenAltimetry: '538'
Date: 2021-02-01 05:44:11 Time specific RGT: '599' OpenAltimetry: '599'
Date: 2021-03-02 04:20:14 Time specific RGT: '1041' OpenAltimetry: '1041'