Getting started with GPM data

Ibrahim N. Mohammed

2022-03-06

NASAaccess package has multiple functions such as `GPMpolyCentroid` and `GPMswat` that download, extract, and reformat rainfall remote sensing data of TRMM and IMERG from NASA servers for grids within a specified watershed shapefile.

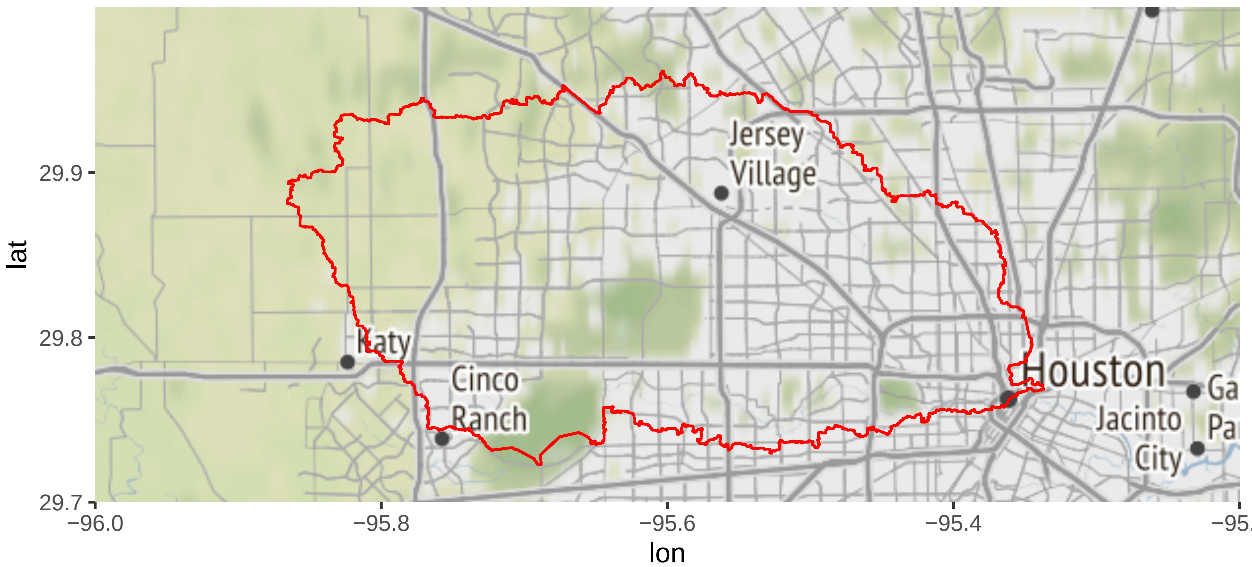
Let's explore `GPMpolyCentroid` and `GPMswat` functions.

Basic use

Let's look at an example watershed that we want to examine near Houston, TX:

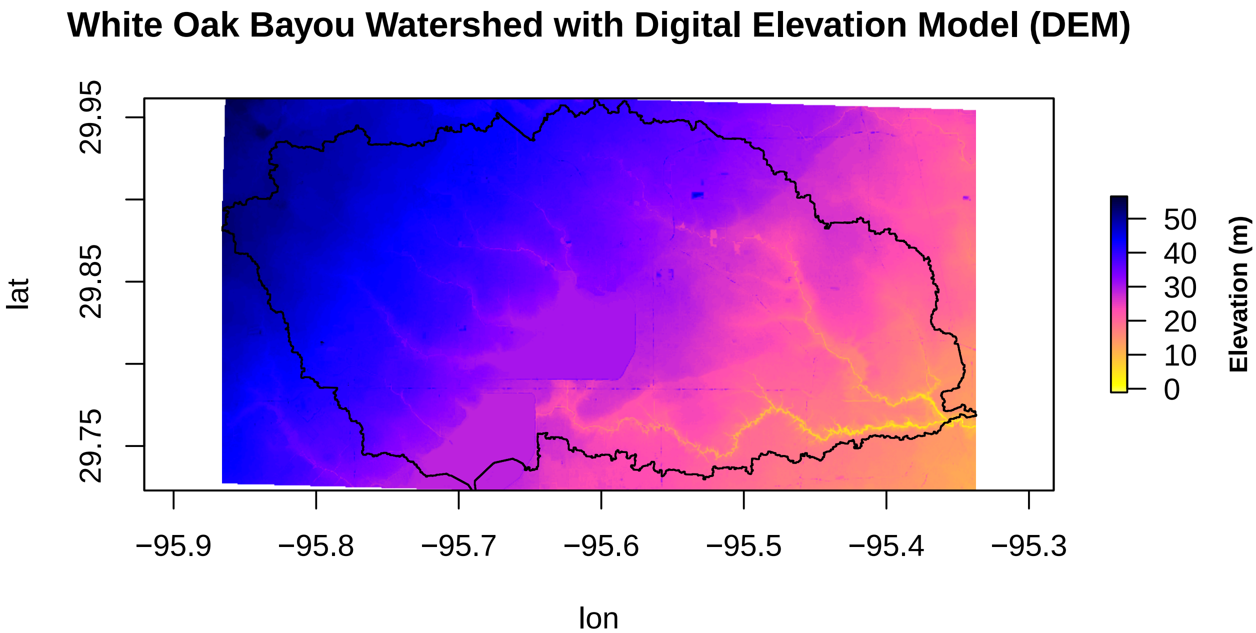
```
library(ggmap)
#> Google's Terms of Service: https://cloud.google.com/maps-platform/terms/.
#> Please cite ggmap if you use it! See citation("ggmap") for details.
library(raster)
library(ggplot2)
library(rgdal)
#> Please note that rgdal will be retired by the end of 2023,
#> plan transition to sf/stars/terra functions using GDAL and PROJ
#> at your earliest convenience.
#>
#> rgdal: version: 1.5-28, (SVN revision 1158)
#> Geospatial Data Abstraction Library extensions to R successfully loaded
#> Loaded GDAL runtime: GDAL 3.2.1, released 2020/12/29
#> Path to GDAL shared files: /Users/imohamme/Library/R/x86_64/4.1/library/sf/gdal
#> GDAL binary built with GEOS: TRUE
#> Loaded PROJ runtime: Rel. 7.2.1, January 1st, 2021, [PJ_VERSION: 721]
#> Path to PROJ shared files: /Users/imohamme/Library/R/x86_64/4.1/library/rgdal/proj
#> PROJ CDN enabled: FALSE
#> Linking to sp version:1.4-6
#> To mute warnings of possible GDAL/OSR exportToProj4() degradation,
#> use options("rgdal_show_exportToProj4_warnings"="none") before loading sp or rgdal.
#> Overwritten PROJ_LIB was /Users/imohamme/Library/R/x86_64/4.1/library/rgdal/proj

#Reading input data
dem_path <- system.file("extdata",
                        "DEM_TX.tif",
                        package = "NASAaccess")

shape_path <- system.file("extdata",
                          "basin.shp",
                          package = "NASAaccess")
```

```r
dem <- raster(dem_path)



shape <- readOGR(shape_path)
#> OGR data source with driver: ESRI Shapefile
#> Source: "/Users/imohamme/Documents/HBS.Task.6056/Software/NASAaccess/inst/extdata/basin.shp", layer:
#> with 1 features
#> It has 4 fields
#> Integer64 fields read as strings:  OBJECTID disID
shape.df <- ggplot2::fortify(shape)
#> Regions defined for each Polygons





#plot the watershed data
myMap <- get_stamenmap(bbox = c(left = -96,
                                bottom = 29.7,
                                right = -95.2,
                                top = 30),
                                            maptype = "terrain",
                                            crop = TRUE,
                                             zoom = 10)
#> Source : http://tile.stamen.com/terrain/10/238/422.png
#> Source : http://tile.stamen.com/terrain/10/239/422.png
#> Source : http://tile.stamen.com/terrain/10/240/422.png
#> Source : http://tile.stamen.com/terrain/10/241/422.png
#> Source : http://tile.stamen.com/terrain/10/238/423.png
#> Source : http://tile.stamen.com/terrain/10/239/423.png
#> Source : http://tile.stamen.com/terrain/10/240/423.png
#> Source : http://tile.stamen.com/terrain/10/241/423.png


ggmap(myMap) +
  geom_polygon(data = shape.df,
               aes(x = long, y = lat, group = group),
               fill = NA, size = 0.5, color = 'red')
```



The geographic layout of the White Oak Bayou watershed example used in this demonstration is depicted above. Whiteoak Bayou is a tributary for the Buffalo Bayou River (Harris County, Texas). In order to use *NASAaccess* we also need a digital elevation model (DEM) raster layer. Let's see the White Oak Bayou watershed DEM and a more closer look at the study watershed example.

```
# create a plot of our DEM raster along with watershed

plot(dem,
     main="White Oak Bayou Watershed with Digital Elevation Model (DEM)",
      col=rev(bpy.colors()),
      xlab='lon',
      ylab='lat',
      legend  = T,
      legend.args=list(text='Elevation (m)',
                       side=4,
                       font=2,
                       line=2.5,
                       cex=0.8))

plot(shape , add = TRUE)
```



Now, let's examine `GPMswat`:

```
library(NASAaccess)

GPMswat(Dir = "./GPMswat/",
                  watershed = shape_path,
                  DEM = dem_path,
                  start = "2020-08-1",
                  end = "2020-08-3")
```

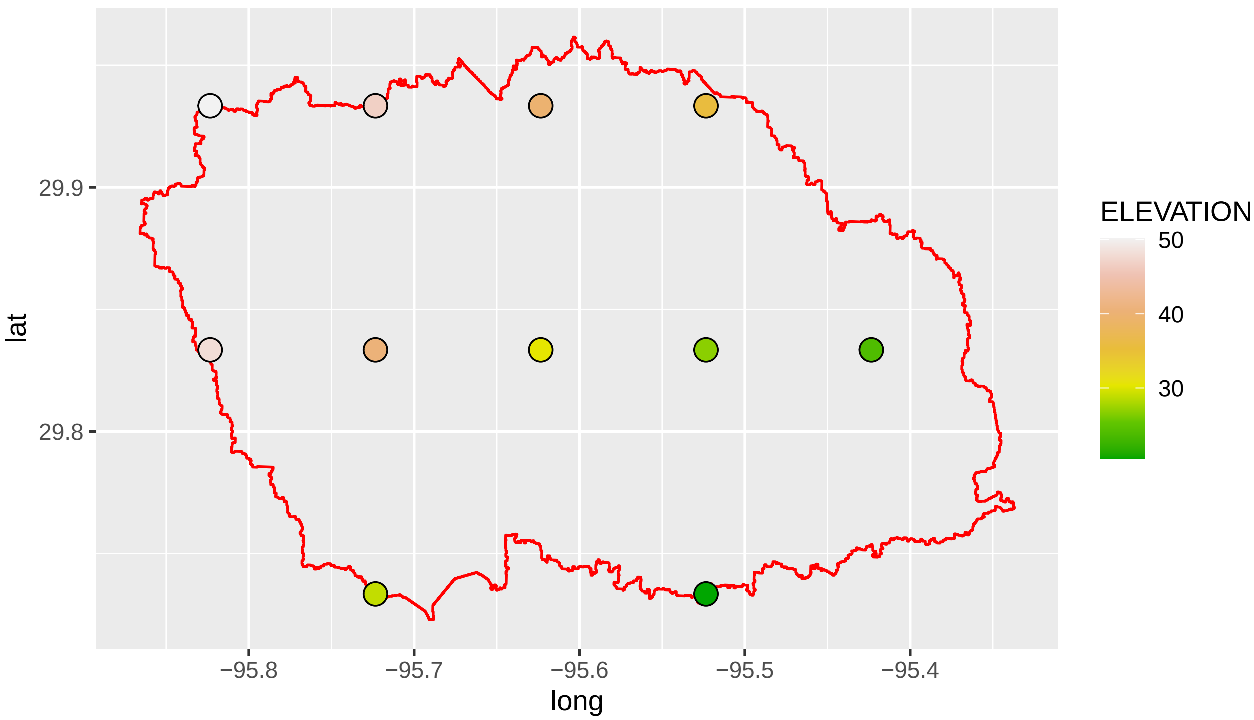
Examining the rainfall station file generated by `GPMswat`

```
GPMswat.precipitationMaster <- system.file('extdata/GPMswat',
                                           'precipitationMaster.txt',
                                           package = 'NASAaccess')

#Reading GPMswat header file
GPMswat.table<-read.csv(GPMswat.precipitationMaster)


head(GPMswat.table)
#>        ID                 NAME      LAT      LONG ELEVATION
#> 1 2160842 precipitation2160842 29.93337 -95.82337  50.16166
#> 2 2160843 precipitation2160843 29.93337 -95.72340  46.68206
#> 3 2160844 precipitation2160844 29.93337 -95.62343  39.72196
#> 4 2160845 precipitation2160845 29.93337 -95.52346  35.58193
#> 5 2164442 precipitation2164442 29.83343 -95.82337  48.02116
#> 6 2164443 precipitation2164443 29.83343 -95.72340  40.47534

dim(GPMswat.table)
#> [1] 11  5
```

`GPMswat` generated ascii table for each available grid located within the study watershed. There are 11 grids within the study watershed and that means 11 tables have been generated. `GPMswat` also generated the rainfall stations file input shown above *GPMswat.table* (table with columns: ID, File NAME, LAT, LONG, and ELEVATION) for those selected grids that fall within the specified watershed.

Now, let's see the location of these generated grid points:

```
ggplot() +
  geom_polygon(data = shape.df,
          aes(x = long, y = lat, group = group),
          fill = NA,
          colour = 'red') +
  geom_point(data=GPMswat.table,
             aes(x=LONG,
                 y=LAT,
                 fill=ELEVATION),
             shape=21,
             size = 4) +
  scale_fill_gradientn(colours = terrain.colors(7))
```



We note here that `GPMswat` has given us all the GPM data grids that fall within the boundaries of the White Oak Bayou study watershed.

The time series rainfall data stored in the data tables (i.e., 11 tables) can be viewed also. looking at reformatted data from the first grid point as listed in the rainfall station file generated by `GPMswat`

```
GPMswat.point.data <- system.file('extdata/GPMswat',
                              'precipitation2160842.txt',
                              package = 'NASAaccess')

#Reading data records
read.csv(GPMswat.point.data)
#>     X20200801
#> 1 32.22795868
#> 2  1.80884695
#> 3  0.07029478
```

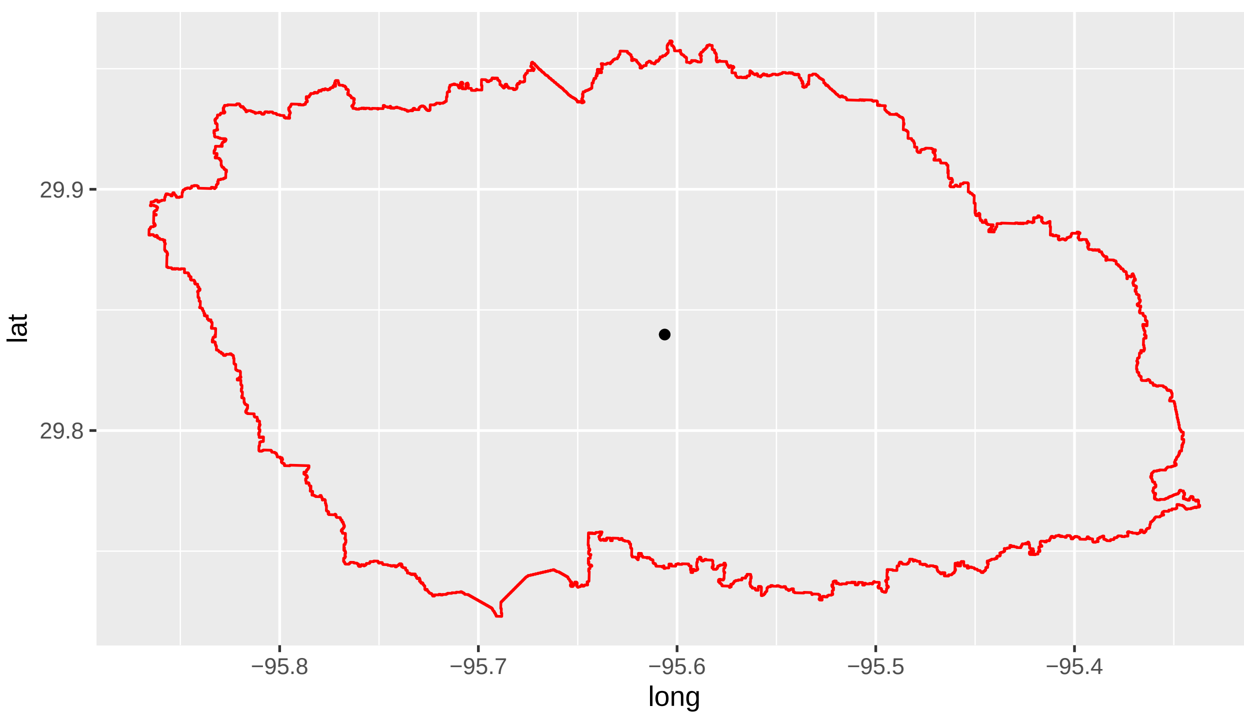
The `GPMswat` has generated a ready format ascii tables that can be ingested easily to the Soil and Water Assessment Tool SWAT model or any other hydrological model of choice.

Now, let's examine `GPMpolyCentroid`.

```
GPMpolyCentroid(Dir = "./GPMpolyCentroid/",
                  watershed = shape_path,
                  DEM = dem_path,
                  start = "2019-08-1",
                  end = "2019-08-3")
```

Examining the rainfall station file generated by `GPMpolyCentroid`

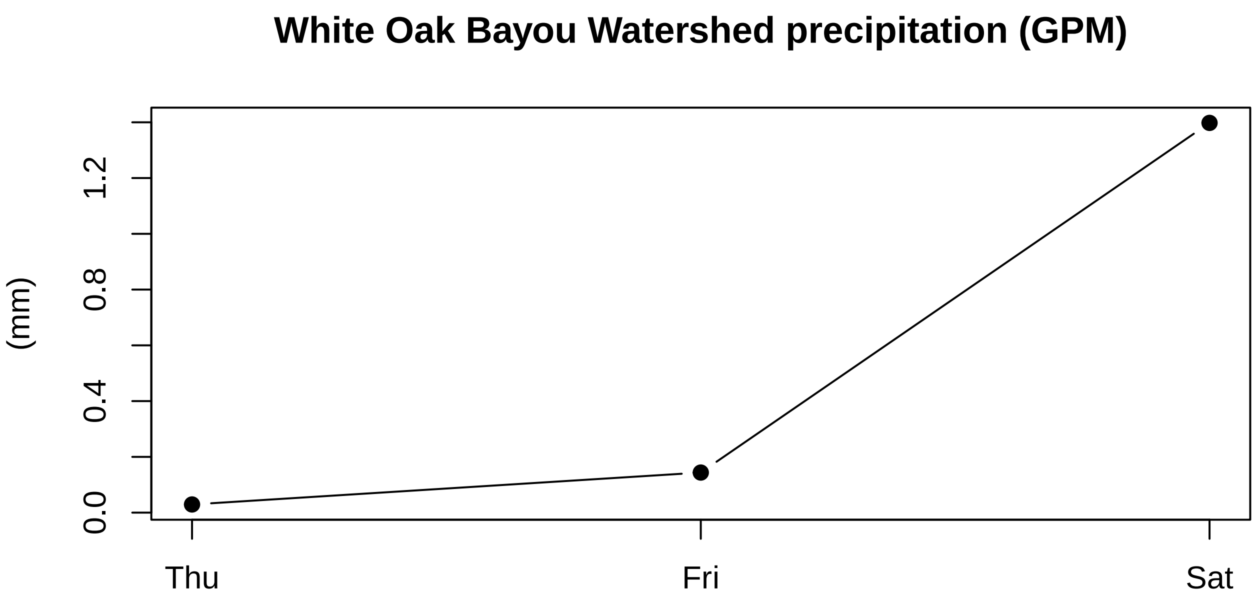
```
GPMpolyCentroid.precipitationMaster <- system.file('extdata/GPMpolyCentroid',
                                                   'precipitationMaster.txt',
                                                   package = 'NASAaccess')

GPMpolyCentroid.precipitation.table <- read.csv(GPMpolyCentroid.precipitationMaster)

#plotting
ggplot() +
  geom_polygon(data = shape.df,
               aes(x = long, y = lat, group = group),
               fill = NA,
               colour = 'red') +
  geom_point(data=GPMpolyCentroid.precipitation.table,
             aes(x=LONG,y=LAT))
```



We note here that `GPMpolyCentroid` has given us the GPM data grid that falls within a specified watershed and assigns a pseudo rainfall gauge located at the centroid of the watershed a weighted-average daily rainfall data.

Let's examine the precipitation data just obtained by `GPMpolyCentroid` over the White Oak Bayou study watershed.

```
GPMpolyCentroid.precipitation.record <- system.file('extdata/GPMpolyCentroid',
                                                    'precipitation1.txt',
                                                    package = 'NASAaccess')

GPMpolyCentroid.precipitation.data <- read.csv(GPMpolyCentroid.precipitation.record)

#since data started on 2019-08-01

days <- seq.Date(from = as.Date('2019-08-01'),
                 length.out = dim(GPMpolyCentroid.precipitation.data)[1], by = 'day')

#plotting the precipitation time series

plot(days, GPMpolyCentroid.precipitation.data [,1],
                                    pch = 19, ylab= '(mm)',
                                    xlab = '',
                                    type = 'b',
     main="White Oak Bayou Watershed precipitation (GPM)")
```



The time series plot above gives the rainfall amounts in (mm) at the centroid of the White Oak Bayou watershed during 2019-August-01 to 2019-August-03.

Built with

```
sessionInfo()
#> R version 4.1.2 (2021-11-01)
#> Platform: x86_64-apple-darwin17.0 (64-bit)
#> Running under: macOS Big Sur 10.16
#>
#> Matrix products: default
#> BLAS:   /Library/Frameworks/R.framework/Versions/4.1/Resources/lib/libRblas.0.dylib
#> LAPACK: /Library/Frameworks/R.framework/Versions/4.1/Resources/lib/libRlapack.dylib
#>
```

```
#> locale:
#> [1] C/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
#>
#> attached base packages:
#> [1] stats     graphics  grDevices utils     datasets  methods   base
#>
#> other attached packages:
#> [1] rgdal_1.5-28     ggmap_3.0.0      ggplot2_3.3.5    sf_1.0-6
#> [5] raster_3.5-15    sp_1.4-6         NASAaccess_3.0.3
#>
#> loaded via a namespace (and not attached):
#>  [1] httr_1.4.2          pkgload_1.2.4       tidyr_1.2.0
#>  [4] brio_1.1.3          highr_0.9           yaml_2.3.5
#>  [7] pillar_1.7.0        lattice_0.20-45     glue_1.6.2
#> [10] digest_0.6.29       colorspace_2.0-3    htmltools_0.5.2
#> [13] plyr_1.8.6          XML_3.99-0.9        pkgconfig_2.0.3
#> [16] s2_1.0.7            purrr_0.3.4         scales_1.1.1
#> [19] terra_1.5-21        jpeg_0.1-9          tibble_3.1.6
#> [22] proxy_0.4-26        farver_2.1.0        generics_0.1.2
#> [25] ellipsis_0.3.2      withr_2.4.3         cli_3.2.0
#> [28] magrittr_2.0.2      crayon_1.5.0        maptools_1.1-2
#> [31] evaluate_0.15       ncdf4_1.19          fansi_1.0.2
#> [34] xml2_1.3.3          foreign_0.8-81      class_7.3-19
#> [37] tools_4.1.2         shapefiles_0.7      RgoogleMaps_1.4.5.3
#> [40] lifecycle_1.0.1     stringr_1.4.0       munsell_0.5.0
#> [43] compiler_4.1.2      e1071_1.7-9         tinytex_0.37
#> [46] rlang_1.0.1         classInt_0.4-3      units_0.8-0
#> [49] grid_4.1.2          rstudioapi_0.13     rjson_0.2.21
#> [52] labeling_0.4.2      bitops_1.0-7        rmarkdown_2.11
#> [55] testthat_3.1.2      wk_0.6.0            gtable_0.3.0
#> [58] codetools_0.2-18    curl_4.3.2          DBI_1.1.2
#> [61] roxygen2_7.1.2      R6_2.5.1            knitr_1.37
#> [64] dplyr_1.0.8         fastmap_1.1.0       rgeos_0.5-9
#> [67] utf8_1.2.2          rprojroot_2.0.2     KernSmooth_2.23-20
#> [70] desc_1.4.0          stringi_1.7.6       Rcpp_1.0.8
#> [73] vctrs_0.3.8         png_0.1-7           tidyselect_1.1.2
#> [76] xfun_0.29
```