rgee: An R package for interacting with Google Earth Engine

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Summary

Google Earth Engine (GEE) (Gorelick et al. 2017) is a cloud-based platform specifically designed for planetary-scale environmental data analysis. Currently, GEE is made up of 3 components. The data catalog which is continuously updated and permits users to access a dataset of over 40 years of satellite imagery for the whole world. The Google's geocomputational infrastructure highly optimized to reduce the time execution of spatial non-recursively procedures. Finally, the Web REST API and the two client libraries (in JavaScript and Python) permits users to interact with the server-side without the necessity to understand the complex system architecture and data distributions models behind GEE. Although the GEE functionality is powerful with more than 800 functions, and the possibility of chaining operations, there are limitations to creating straightforward input/output pipelines, quality static visualization, metadata display, and efficient management of Earth Engine asset resources. This becomes a more challenging task outside the Python Earth Engine API (Markert 2019).

This paper introduces **rgee**, an Earth Engine client library for R. The goal of **rgee** is to allows users to leverage the strengths of the R spatial ecosystem and Google Earth Engine in the same workflow. All the classes and the existing functionality of the two Google's supported client libraries can be called through the dollar sign (`$`). `rgee` adds several new features such as (i) new I/O design, (ii) multiple user support, (iii) easily extraction of time series, (iv) asset manage interface, and (v) metadata display, also with `rgee` is possible the execution of Earth Engine Python code from within R which make the translation of large Python projects unnecessary.

Features

I/O Enhanced

rgee implements several functions to support the download/upload of image and vector datasets (Table 1 and Table 2). For instance, to download images located on the server-side you might use either `ee_image_as_raster` or `ee_image_as_stars`. All the direct download functions (EE server-side to local) implemented in `rgee` have the option to download via using an intermediate container (Google Drive or Google Cloud Storage) or a REST call ("$getInfo"). Although the last option permits users a quick download, there is a limitation of 262144 pixels (for images) or 5000 elements (for featurecollections) by request which makes it not recommendable for large objects. The others implemented functions (Table 1) will permit you to create more customized download workflows, for instance, using `ee_image_to_drive` and `ee_drive_to_local` users could create scripts which save results in a `.TFRecord` rather than a `.GeoTIFF` format. The upload process follows the same logic. In **rgee** we implement `raster_as_ee`, `stars_as_ee` for upload images and `sf_as_ee` for vector data. Large uploads are just possible through a Google Cloud Storage account active.

Table 1: Download functions provided by package rgee.

		FROM	TO	RETURN
Image	ee_image_to_drive	EE server-side	Drive	Unstarted task

		FROM	TO	RETURN
	ee_image_to_gcs	EE server-side	Cloud Storage	Unstarted task
	ee_image_to_asset	EE server-side	EE asset	Unstarted task
	ee_as_raster	EE server-side	Local	RasterStack object
	ee_as_stars	EE server-side	Local	Proxy-stars object
Table	ee_table_to_drive	EE server-side	Drive	Unstarted task
	ee_table_to_gcs	EE server-side	Cloud Storage	Unstarted task
	ee_table_to_asset	EE server-side	EE asset	Unstarted task
	ee_as_sf	EE server-side	Local	sf object
Generic	ee_drive_to_local	Drive	Local	object filename
	ee_gcs_to_local	Cloud Storage	Local	GCS filename

Table 2: Upload functions provided by package rgee.

		FROM	TO	RETURN
Image	gcs_to_ee_image	Cloud Storage	EE asset	EE Asset ID
	raster_as_ee	Local	EE asset	EE Asset ID
	stars_as_ee	Local	EE asset	EE Asset ID
Table	gcs_to_ee_table	Cloud Storage	EE asset	EE Asset ID
	sf_as_ee	Local	EE asset	EE Asset ID
Generic	local_to_gcs	Local	Cloud Storage	GCS filename

Multiple users

`rgee` offers users the possibility to arrange multiple credentials (Google Earth Engine, Google Drive, and Google Cloud Storage) for multiple users through the function `ee_Initialize` (a wrapper around `ee$Initialize`). This function will permit to change between users quickly what could be used to parallelize exporting and importing tasks from the client-side. For instance, if a group of researchers wants to analyze the deforestation, the code bellow will permit them to obtain results three-times faster:

```
library(foreach)
library(rgee)

google_account <- c("csaybar", "ryali93", "lbautista")

foreach(account = google_account, .combine = "c") %dopar% {
  ee_Initialize(gmail)
  ic_results <- temporal_deforestation(split = ...)
  ee_imagecollection_to_local(ic_results)
} -> results
```

Extraction of time series

`rgee` can extract values from `ee.Image` and `ee.ImageCollection` at the location of `ee.Geometry`, `ee.Feature`, `ee.FeatureCollection` and `sf` objects. If the geometry is a polygon, users can summarize the values considering in-built EE reducer functions that return one value. The code below explains how to extract the average areal rainfall for precipitation mean composite.

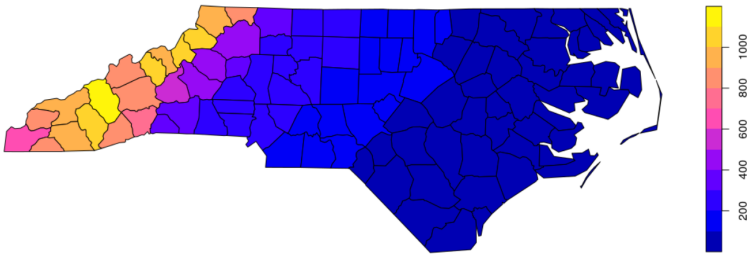
```
library(rgee)
library(sf)

ee_Initialize()
```

```
# Image or ImageCollection (mean composite)
terraclimate <- ee$ImageCollection("IDAHO_EPSCOR/TERRACLIMATE")$
  filterDate("2001-01-01", "2002-01-01")$
  map(function(x) x$select("pr"))$
  mean()$rename("pp_mean")

# Define a geometry
nc <- st_read(system.file("shape/nc.shp", package = "sf"))

# Extract the average areal rainfall
ee_nc_rain <- ee_extract(terraclimate, nc, sf = TRUE)
plot(ee_nc_rain["pp_mean"])
```



Asset Manage Interface

`rgee` inspired in previous works (Roy 2020) implement an interface to batch actions on assets. This interface is composed for a series of function with the prefix ee_manage_*. The Asset Manage Interface enables the creation and elimination of imagecollections and folders, moving and copy assets, set and delete properties, define the access control lists, and to manage or cancel tasks. This interface extending capabilities of the existing GEE data module (ee.data.*). For instance, users could task

```
library(rgee)
ee_Initialize()

server_path <- "LANDSAT/LC08/C01/T1/"
user_asset_path <- ee_get_assethome()

ee_manage_copy(
  path_asset = paste0(server_path,"/LC08_044034_20140318"),
  final_path = paste0(user_asset_path,"/LC08_044034_20140318")
)
```

Metadata display

`rgee` trought `ee_print` can fetch and return metadata (Fig .2) about `ee.Geometry`, `ee.Feature`, `ee.FeatureCollection`, `ee.Image` and `ee.ImageCollections` objects. With `ee_print` the acquire of information about number of images or features, number of bands or geometries, number of pixels, geotransform, datatype, properties and aproximate size of the object can be made with a single line of code. `ee_print` was designed to be used inside debugging pipelines (e.g. ee.Image.aside(ee_print))

```
library(rgee)

ee_Initialize()
srtm <- ee$Image("CGIAR/SRTM90_V4")
ee_print(srtm)
```

```
──────────────────────────────────────────────────────── Earth Engine Image ──
Image Metadata:
 - Class                       : ee$Image
 - Number of Bands             : 12
 - Bands names                 : B1 B2 B3 B4 B5 B6 B7 B10 B11 sr_aerosol pixel_qa radsat_qa
 - Number of Properties        : 24
 - Number of Pixels*           : 683893728
 - Approximate size*           : 1.02 GB
Band Metadata (img_band = B1):
 - EPSG (SRID)                 : 32642
 - proj4string                 : +proj=utm +zone=42 +datum=WGS84 +units=m +no_defs
 - Geotransform                : 30 0 520485 0 -30 2672115
 - Nominal scale (meters)      : 30
 - Dimensions                  : 7413 7688
 - Number of Pixels            : 56991144
 - Data type                   : INT
 - Approximate size            : 86.96 MB
 ──────────────────────────────────────────────────────────────────────────────
```

Figure 1: ee.Image metadata

Availability

`rgee` is open source software made available under the Apache v2 license. It can be installed through CRAN (——) using: install.packages("——"). `rgee` can also be installed from its GitHub repository using the remotes package: remotes::install_github("——-").

References

Gorelick, Noel, Matt Hancher, Mike Dixon, Simon Ilyushchenko, David Thau, and Rebecca Moore. 2017. "Google Earth Engine: Planetary-Scale Geospatial Analysis for Everyone." *Remote Sensing of Environment* 202. Elsevier: 18–27.

Markert, Kel. 2019. "Cartoee: Publication Quality Maps Using Earth Engine." *Journal of Open Source Software* 4 (33): 1207.

Roy, Samapriya. 2020. *samapriya/gee_asset_manager_addon: GEE Asset Manager with Addons* (version 0.4.6). Zenodo. https://doi.org/10.5281/zenodo.3772053.