NDVI (versão 1)

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1. Introdução

O documento tem como propósito auxiliar no entendimento do *script* na geração de imagens NDVIs e RGBs. A sua principal função é automatizar alguns processos repetitivos durante a geração dos produtos, tais como: leitura de arquivos, recortes, cálculo do NDVI e exportação dos produtos gerados.

2. Importação das bibliotecas

Os pacotes são conjunto de funções que nos auxiliarão a desenvolver um determinado resultado. Boa parte desses pacotes podem ser encontrados na base oficial do *R (CRAN)*. Antes de importar as bibliotecas, é importante realizamos uma limpeza na mémoria do R.

```
#Limpar memória
rm(list=ls(all=TRUE))
```

```
# Importando pacotes
library(raster)
```

```
## Carregando pacotes exigidos: sp
```

```
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: 1.5-27, (SVN revision 1148)
## 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: C:/Users/igor.souza/Documents/R/R-4.1.1/library/rgdal/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: C:/Users/igor.souza/Documents/R/R-4.1.1/library/rgdal/proj
## PROJ CDN enabled: FALSE
## Linking to sp version:1.4-5
## 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 C:/Users/igor.souza/Documents/R/R-4.1.1/library/rgdal/proj
```

3. Carregando diretório

As linhas abaixo, nos permite selecionar o local, no qual, importaremos nossos arquivos e exportaremos o produto final. É de importancia criar uma pasta no diretório no disco C:. Observe abaixo, o caminho de pasta a ser criado.

4. Criando uma lista para armazenar nossos arquivos

Dentro da pasta R criada anteriormente, crie uma pasta chamada RGB, NDVI e TALHAO. Em cada pasta, você deverá colocar as imagens selecionadas e o poligono. Ao executar as linhas abaixo, é observado o que contém armazenado em lista em cada pasta.

```
RGB <- list.files(path="RGB", pattern = ".tif", full.names = TRUE)
SHP <- list.files(path="TALHAO", pattern = ".shp", full.names = TRUE)
INDICE <- list.files(path="NDVI", pattern = ".tif", full.names = TRUE)

RGB
```

```
## [1] "RGB/S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif"
```

```
SHP
```

```
## [1] "TALHAO/co_1.shp"
```

```
INDICE
```

```
## [1] "NDVI/S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_r8g11b4.tif"
```

5. Lendo os arquivos em suas respectivas Pastas

5.1 RGB

A executar, todas as imagens da pasta são carregadas para a memória com o repectivos nomes.

```
## Criando um lista vazia para as Imagens RGB

RGB_STACK<-c()
```

```
## Leitura de todas imagens na Pasta RGB

r_name <- list.files(path="RGB",full.names = F)

for(i in RGB){ RGB_STACK[[i]]<- stack(i)}

names(RGB_STACK)<- c(r_name)

RGB_STACK
```

```
## $S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## class      : RasterStack
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## names      : TCI_R, TCI_G, TCI_B
## min values :     0,     0,     0
## max values :   255,   255,   255
```

5.2 NDVI

```
NDVI_STACK<-c()

r_name1 <- list.files(path="NDVI",full.names = F)

for(g in INDICE){
  NDVI_STACK[[g]]<- stack(g)}



names(NDVI_STACK)<- c(r_name1)

NDVI_STACK
```

```
## $S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_r8g11b4.tif
## class      : RasterStack
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## names      :    B8,   B11,    B4
## min values :     0,     0,     0
## max values : 65535, 65535, 65535
```

IMPORTANTE: Em `bandas<-NDVI_STACK[[1]]` . O número 1, corresponde a ordem da imagem na pasta NDVI. Dessa maneira ao alterar a numeração, por exemplo, para 2, a leitura será do segundo arquivo na pasta, é comum que seja solicitada imagens em datas distintas. No entanto, em nosso exemplo temos somente uma imagem em cada pasta, portanto, a númeração deverá ser 1. O resultado desta ação selecionou a imagem: `S2B_MSIL2A_20211211T134209_N0301_R124_T22KDF_20211211T161405_r8g11b4.tif` . Lembrando que esse número deverá se repetir nas linhas em que for solicitado.

```
bandas<-NDVI_STACK[[1]]
```

5.3 TALHAO

```
TALHAO<-c()
for(j in SHP){TALHAO[[j]]<- sf::st_read(j)}
```

```
## Reading layer `co_1' from data source `C:\@IGOR\R\TALHAO\co_1.shp' using driver `ESRI Shap
efile'
## Simple feature collection with 9 features and 6 fields
## Geometry type: POLYGON
## Dimension:      XY
## Bounding box:   xmin: -50.29243 ymin: -17.2586 xmax: -50.25943 ymax: -17.22538
## CRS:            NA
```

6. Cálculo do Índice de Diferença Normalizada Para Sentinel (NDVI)

Os números em `sat_ndvi <- (bandas[[1]] - bandas[[3]]) / (bandas[[1]] + bandas[[3]])` corresponde a ordem em que a banda espectral encontra-se na imagem. Logo, o número 1 corresponde a Banda B8 (Infravermelho próximo) e 3 (vermelho). o Resultado da expressão matemática, é um índice que varia de -1 a +1.

```
sat_ndvi_list<-list() ## Criando uma lista para armazenar o produto dos cálculos

sat_ndvi <- (bandas[[1]] - bandas[[3]]) / (bandas[[1]] + bandas[[3]])

NDVI_STACK<- stack(sat_ndvi)

NDVI_STACK
```
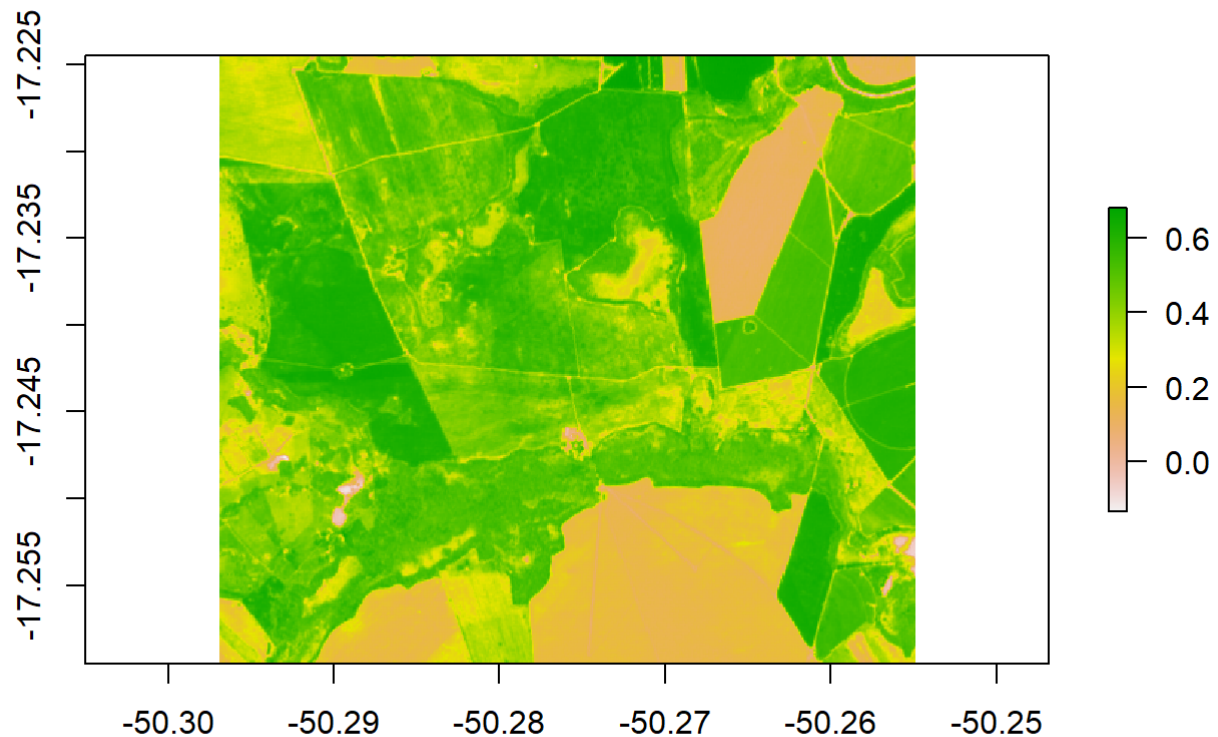
```
## class       : RasterStack
## dimensions  : 390, 468, 182520, 1  (nrow, ncol, ncell, nlayers)
## resolution  : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## names       :      layer
## min values  : -0.1334746
## max values  :  0.6812573
```

Visualização NDVI

```
plot(sat_ndvi)
```

7. Recortes das imagens por talhão.

Após carregar as imagens RGB e a realização do cálculo NDVI. Necessitamos exportar nosso produto final por talhão, com o propósito de realizarmos posteriormente nossa classificação das cores no Qgis. Neste momento é importante a alteração em `dataoutput<-data.frame(data=r_name[1])`, para o número corresponde a imagem que você está utilizando, nesse caso [1]. Esse momento é de extrema importancia, pois a partir desse momento, conseguimos criar um forma pra nomear os arquivos de saída conforme a data da imagem e o talhão.

```
CO<-TALHAO[[1]]

TA<-CO$TALHAO

output <- data.frame(t = TA)


dataoutput<-data.frame(data=r_name[1]) ##ALTERA O NÚMERO, PARA MUDAR A IMAGEM

output
```

```
##     t
## 1 G_2
## 2 G_3
## 3 G_4
## 4 G_5
## 5 G_1
## 6 G_4
## 7 G_2
## 8 G_3
## 9 G_5
```

```
dataoutput
```

```
##                                                                      data
## 1 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
```

```
names_data<-paste("RGB_",output$t,dataoutput$data)

LISTA<-list()
```

7.1 Recorte RGB

Mais uma vez precisamos alterar a númeração de `RGB_STACK[[1]]` . Nesse momento é realizado os corte por talhão, sendo armazendo em uma lista `LISTA<-list()` .

```
RGB_STACK
```

```
## $S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## class      : RasterStack
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## names      : TCI_R, TCI_G, TCI_B
## min values :     0,     0,     0
## max values :   255,   255,   255
```

```
for (c in 1:length(output$t)) {LISTA[c]<- mask(RGB_STACK[[1]], CO[CO$TALHAO==output$t[c],])

}
```

```
## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, c, value = mask(RGB_STACK[[1]], CO[CO$TALHAO == :
## implicit list embedding of S4 objects is deprecated
```

```
names(LISTA)<- c(names_data)
LISTA
```

```
## $`RGB_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : TCI_R, TCI_G, TCI_B
## min values :    41,    57,    39
## max values :   255,   255,   255
##
##
## $`RGB_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : TCI_R, TCI_G, TCI_B
## min values :    29,    54,    33
## max values :   130,   129,    73
##
##
## $`RGB_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : TCI_R, TCI_G, TCI_B
## min values :    28,    54,    33
## max values :   148,   127,    74
##
##
## $`RGB_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : TCI_R, TCI_G, TCI_B
## min values :    25,    48,    30
## max values :   108,    87,    63
##
##
## $`RGB_ G_1 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
```

```
## names       : TCI_R, TCI_G, TCI_B
## min values :    24,     45,     29
## max values :   154,     89,     59
##
##
## $`RGB_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : memory
## names       : TCI_R, TCI_G, TCI_B
## min values :    28,     54,     33
## max values :   148,    127,     74
##
##
## $`RGB_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : memory
## names       : TCI_R, TCI_G, TCI_B
## min values :    41,     57,     39
## max values :   255,    255,    255
##
##
## $`RGB_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : memory
## names       : TCI_R, TCI_G, TCI_B
## min values :    29,     54,     33
## max values :   130,    129,     73
##
##
## $`RGB_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : memory
## names       : TCI_R, TCI_G, TCI_B
## min values :    25,     48,     30
## max values :   108,     87,     63
```

Apesar das várias mensagens de "Warning in"(Somente um alerta), O processo foi executado com sucesso.

7.2 Recorte NDVI

Agora repetindo mesmo procedimento para o NDVI.

```
LISTA_NDVI<-list()

for (y in 1:length(output$t)) {LISTA_NDVI[y]<- mask(sat_ndvi, CO[CO$TALHAO==output$t[y],])
}
```

```
## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated

## Warning in `[<-`(`*tmp*`, y, value = mask(sat_ndvi, CO[CO$TALHAO ==
## output$t[y], : implicit list embedding of S4 objects is deprecated
```

```
names_data2<-paste("NDVI_",output$t,dataoutput$data)
names(LISTA_NDVI)<- c(names_data2)
LISTA_NDVI
```

```
## $`NDVI_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.05102954, 0.5903614  (min, max)
##
##
## $`NDVI_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.1956137, 0.6270208  (min, max)
##
##
## $`NDVI_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.178557, 0.6248548  (min, max)
##
##
## $`NDVI_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.2152936, 0.6504935  (min, max)
##
##
## $`NDVI_ G_1 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.1419774, 0.6445078  (min, max)
##
##
```

```
## $`NDVI_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.178557, 0.6248548  (min, max)
##
##
## $`NDVI_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.05102954, 0.5903614  (min, max)
##
##
## $`NDVI_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.1956137, 0.6270208  (min, max)
##
##
## $`NDVI_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : memory
## names      : layer
## values     : 0.2152936, 0.6504935  (min, max)
```

8. EXPORTANDO PRODUTOS

Por fim, exportaremos nossos produtos

```
mapply(writeRaster, LISTA, names(LISTA), 'GTiff',overwrite= TRUE)
```

```
## $`RGB_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : RGB_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## names      : RGB__G_2_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_2_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_2_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                              41,
57,                                                            39
## max values :                                                             255,
255,                                                           255
##
##
## $`RGB_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : RGB_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## names      : RGB__G_3_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_3_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_3_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                              29,
54,                                                            33
## max values :                                                             130,
129,                                                           73
##
##
## $`RGB_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : RGB_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## names      : RGB__G_4_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_4_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_4_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                              28,
54,                                                            33
## max values :                                                             148,
127,                                                           74
##
##
## $`RGB_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : RGB_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
```

```
## names        : RGB__G_5_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_5_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_5_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                                    25,
48,                                                                  30
## max values :                                                                   108,
87,                                                                  63
##
##
## $`RGB_ G_1 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448   (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : RGB_ G_1 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## names       : RGB__G_1_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_1_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_1_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                                    24,
45,                                                                  29
## max values :                                                                   154,
89,                                                                  59
##
##
## $`RGB_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448   (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : RGB_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## names       : RGB__G_4_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_4_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_4_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                                    28,
54,                                                                  33
## max values :                                                                   148,
127,                                                                 74
##
##
## $`RGB_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448   (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : RGB_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## names       : RGB__G_2_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_2_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_2_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                                    41,
57,                                                                  39
## max values :                                                                   255,
255,                                                                 255
##
```

```
## 
## $`RGB_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : RGB_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## names      : RGB__G_3_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_3_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_3_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                                          29,
54,                                                                       33
## max values :                                                                         130,
129,                                                                      73
## 
## 
## $`RGB_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterBrick
## dimensions : 390, 468, 182520, 3  (nrow, ncol, ncell, nlayers)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : RGB_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif
## names      : RGB__G_5_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.1,
RGB__G_5_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.2, RGB__G_5_S2B_MSI
L2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.3
## min values :                                                                          25,
48,                                                                       30
## max values :                                                                         108,
87,                                                                       63
```

```
mapply(writeRaster, LISTA_NDVI, names(LISTA_NDVI), 'GTiff', overwrite= TRUE)
```

```
## $`NDVI_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : NDVI_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
## f
## names      : NDVI__G_2_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values     : 0.05102954, 0.5903614  (min, max)
##
##
## $`NDVI_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : NDVI_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
## f
## names      : NDVI__G_3_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values     : 0.1956137, 0.6270208  (min, max)
##
##
## $`NDVI_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : NDVI_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
## f
## names      : NDVI__G_4_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values     : 0.178557, 0.6248548  (min, max)
##
##
## $`NDVI_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : NDVI_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
## f
## names      : NDVI__G_5_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values     : 0.2152936, 0.6504935  (min, max)
##
##
## $`NDVI_ G_1 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class      : RasterLayer
## dimensions : 390, 468, 182520  (nrow, ncol, ncell)
## resolution : 8.983153e-05, 8.983153e-05  (x, y)
## extent     : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs        : +proj=longlat +datum=WGS84 +no_defs
## source     : NDVI_ G_1 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
```

```
f
## names       : NDVI__G_1_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values      : 0.1419774, 0.6445078  (min, max)
##
##
## $`NDVI_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterLayer
## dimensions  : 390, 468, 182520  (nrow, ncol, ncell)
## resolution  : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : NDVI_ G_4 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
f
## names       : NDVI__G_4_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values      : 0.178557, 0.6248548  (min, max)
##
##
## $`NDVI_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterLayer
## dimensions  : 390, 468, 182520  (nrow, ncol, ncell)
## resolution  : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : NDVI_ G_2 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
f
## names       : NDVI__G_2_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values      : 0.05102954, 0.5903614  (min, max)
##
##
## $`NDVI_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterLayer
## dimensions  : 390, 468, 182520  (nrow, ncol, ncell)
## resolution  : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : NDVI_ G_3 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
f
## names       : NDVI__G_3_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values      : 0.1956137, 0.6270208  (min, max)
##
##
## $`NDVI_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.tif`
## class       : RasterLayer
## dimensions  : 390, 468, 182520  (nrow, ncol, ncell)
## resolution  : 8.983153e-05, 8.983153e-05  (x, y)
## extent      : -50.29694, -50.2549, -17.25951, -17.22448  (xmin, xmax, ymin, ymax)
## crs         : +proj=longlat +datum=WGS84 +no_defs
## source      : NDVI_ G_5 S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI.ti
f
## names       : NDVI__G_5_S2B_MSIL2A_20220216T133219_N0400_R081_T22KEG_20220216T164142_TCI
## values      : 0.2152936, 0.6504935  (min, max)
```