

ISRCartoGIS 2025

Analyzing Spatial Data with R

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Ben Gurion University, Sde Boker

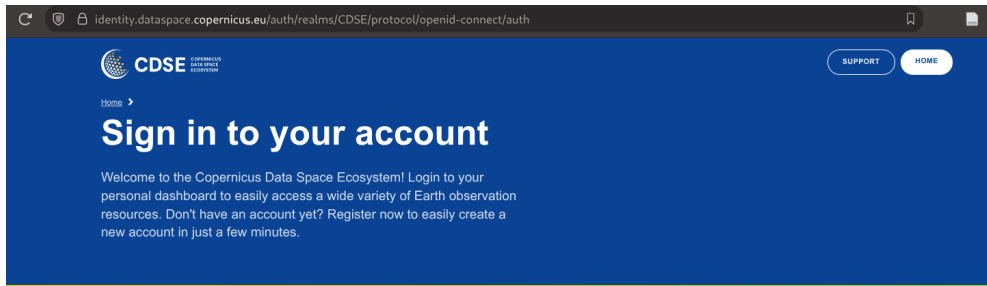
18/09/2025



- Browse and download;
 - ▶ Manual search;
 - ▶ By date, area of interest, satellite mission, cloud cover;
 - ▶ Download one by one, or collect in "basket";
 - ▶ Portals for several remote sensing suppliers.

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- STAC web service;
 - ▶ Spatial Temporal Asset Catalog (**STAC**);
 - ▶ Manual search;
 - ▶ More fine grained search;
 - ▶ Allows for scripted download;
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 - ▶ Portals for several remote sensing suppliers.
- Scripted - Interface with API
 - ▶ Most flexible;
 - ▶ Processing "in the cloud";
 - ▶ Automated time series;
 - ▶ Reproducible.



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- ✓ Follow your credits and orders

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Browse and Download



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copernicus BROWSER EN Micha Silver VISUALISE SEARCH

SH DASHBOARD WORKSPACE 1

SEARCH CRITERIA:

Product name

To apply a location filter, please define an AOI or POI

DATA SOURCES:

- SENTINEL-1 Filters →
- SENTINEL-2 Filters →
- SENTINEL-3 Filters →
- SENTINEL-5P Filters →
- SENTINEL-6 Filters →
- CCM Optical Filters →
- CCM DEM Filters →
- CCM SAR Filters →
- GLOBAL-MOSAICS Filters →
- CLMS Land Cover and Land Use Mapping Filters →
- CLMS Bio-geophysical Parameters Filters →

Leaflet | © OpenStreetMap contributors - Disclaimer, © Sentinel Hub

Lat: 40.86, Lng: 0.73 500 km

Browse and Download



earthexplorer.usgs.gov

An official website of the United States government [Here's how you know](#)

USGS
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Search Criteria **Data Sets** Additional Criteria Results

2. Select Your Data Set(s)

Check the boxes for the data set(s) you want to search. When done selecting data set(s), click the *Additional Criteria* or *Results* buttons below. Click the plus sign next to the category name to show a list of data sets.

☐ Use Data Set Prefilter [\(What's This?\)](#)

Data Set Search:

- ☒ Digital Maps
- ☐ EO-1
- ☐ Global Fiducials
- ☐ HCMM
- ☐ ISERV
- ☐ Land Cover
- ☒ Landsat
 - ☐ Landsat Collection 2 Level-3 Science Products
 - ☐ Landsat C2 U.S. Analysis Ready Data (ARD)
 - ☐ Landsat Collection 2 Level-2
 - ☐ Landsat 8-9 OLI/TIRS C2 L2
 - ☐ Landsat 7 ETM+ C2 L2
 - ☐ Landsat 4-5 TM C2 L2
 - ☐ Landsat Collection 2 Level-1
 - ☐ Landsat C2 Atmospheric Auxiliary Data
 - ☐ Landsat Collection 2 DEM
 - ☐ Landsat Legacy

Search Criteria Summary (Show) Clear Search Criteria

(46° 42' 57" N, 013° 31' 37" E) Options



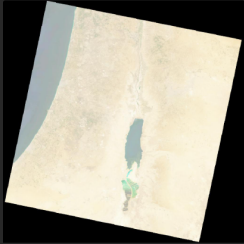
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Home / collection02 / level-2 / standard / oli-tirs / 2022 / 174 / 038 / LC08_L2SP_174038_20220611_20220617_02_T1

< LC08_L2SP_174038_20220611_20220617_02_T1_SR >

Surface Reflectance

PREVIEW THUMBNAIL ASSETS BANDS



Properties

datetime:	2022-06-11T08:11:14.103513Z
eo:cloud_cover:	0
view:sun_azimuth:	108.83675806
view:sun_elevation:	68.92767986
platform:	LANDSAT_8
instruments:	["OLI", "TIRS"]
view:off_nadir:	0
landsat:cloud_cover_land:	0
landsat:wrs_type:	2
landsat:wrs_path:	174
landsat:wrs_row:	038
landsat:scene_id:	LC81740382022162LGN00
landsat:collection_category:	T1



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<

LC08_L2SP_174038_20220611_20220617_02_T1_SR

>

Surface Reflectance

PREVIEW

THUMBNAIL

ASSETS

BANDS

Name	Content-Type
thumbnail	image/jpeg
reduced_resolution_browser	image/jpeg
index	text/html
MTL.json	application/json
coastal	image/vnd.stac.geotiff; cloud-optimized=true
blue	image/vnd.stac.geotiff; cloud-optimized=true
green	image/vnd.stac.geotiff; cloud-optimized=true
red	image/vnd.stac.geotiff; cloud-optimized=true
nir08	image/vnd.stac.geotiff; cloud-optimized=true

Properties

datetime: 2022-06-11T08:11:14.103513Z

eo:cloud_cover: 0

view:sun_azimuth: 108.83675806

view:sun_elevation: 68.92767986

platform: LANDSAT_8

instruments: ["OLI", "TIRS"]

view:off_nadir: 0

landsat:cloud_cover_land: 0

landsat:wrs_type: 2

landsat:wrs_path: 174

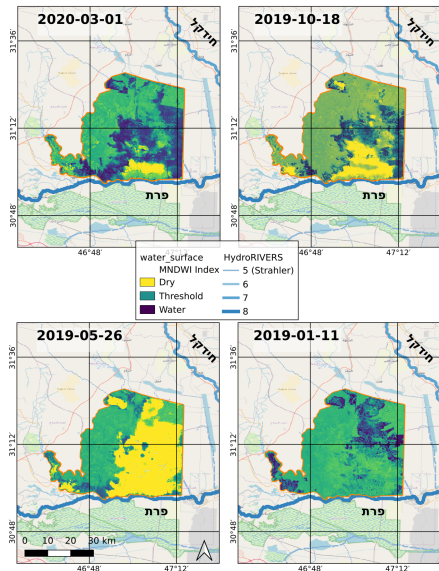
landsat:wrs_row: 038

landsat:scene_id: LC81740382022162LGN00

landsat:collection_category: T1

Shortcomings of "Browse and Download"

Central Marshes
Southern Iraq



Research requires:

- long time span of images;
- one or more calculated indices;
- comparing multiple study areas;
- reproducible procedure.



- Broad collection of R-spatial packages;
- Ecology (`dismo`, `landscapemetrics` and other packages);
- Point pattern analysis (`spatstat` package);
- Spatial statistics (`gstat` and many others);
- Cartography and Visualization (`leaflet`, `ggmap`, `tmap`);



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- Ecology (`dismo`, `landscapemetrics` and other packages);
- Point pattern analysis (`spatstat` package);
- Spatial statistics (`gstat` and many others);
- Cartography and Visualization (`leaflet`, `ggmap`, `tmap`);
- Machine Learning (`mlr3`, `caret` etc.);
- Spatial analysis incorporated into overall work flow;
- Support;
- Reproducible.

- RSpatial: <https://rspatial.org>
- Geocompr (online book): <https://r.geocompx.org>
- R-Spatial (online book): <https://r-spatial.org/book/>
- CRAN spatial task view: <https://cran.r-project.org/web/views/Spatial.html>
- R-SIG-Geo (maillist): <https://stat.ethz.ch/mailman/listinfo/R-SIG-Geo/>

- Spatial packages: `terra`, `sf`, `stars`;
- Cartography and Visualization: `ggplot2`, `ggmap`, `leaflet`, `tmap`;
- Statistics: `dplyr`, `stats`, `tidyr`;

Installation of basic spatial packages:

```
install.packages(c("terra", "sf", "dplyr",  
  "remotes", "ggplot2", "leaflet"), dependencies = TRUE)
```

Installation of packages specifically for remote sensing:

```
install.packages(c("sits", "CDSE", "RStoolbox"), dependencies = TRUE)  
  
devtools::install_github("spatialstatisticsupna/rsat",  
  build_vignettes=TRUE)
```

- Interface to Copernicus DataSpace Ecosystem^a;
- Requires registration, and creating authentication token (no cost);

^a<https://dataspace.copernicus.eu>



- Interface to Copernicus DataSpace Ecosystem^a;
- Requires registration, and creating authentication token (no cost);
- Search, filter, crop to study area, prepare indices, and download results;
- Most of the work "in the cloud";

^a<https://dataspace.copernicus.eu>



```
library(CDSE)
tok <- GetOAuthToken(id = xxxxxxxxx, secret = yyyyyyyyyy)
img_list <- SearchCatalog(aoi,      # Study Area
  from = "2019-01-01",             # from/to dates
  to = "2023-12-31",
  collection = "sentinel-2-l2a",   # Sentinel-2 collection,
  token = tok)                    # Auth token

rast_list <- lapply(img_list, function(i) {
  r1 <- GetImage(aoi = aoi, # Area of Interest
    time_range = as.Date(i$acquisitionDate), #image acquisition date
    script = "MNDWI_masked.js", # javascript to prepare index
    collection = "sentinel-2-l2a", # Sentinel-2 collection
    format = "image/tiff",        # Output format
    token = tok)                  # Auth token
  return(r1) })
```

- "Satellite Image Time Series Analysis";
- Interface to multiple data source, using STAC protocol:
 - ▶ Amazon Web Service (AWS) - requires fee;
 - ▶ Microsoft Planetary Computer (MPC) - no cost;
 - ▶ Digital Earth Africa (DEAFRICA);
 - ▶ Harmonized Landsat Sentinel (HLS) - open, high temporal resolution;
 - ▶ others...



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 - ▶ others...
- Search, crop to study area, and download results;
- Regularize time series;
- Landcover classification.



```
library(sits)
sits_list_collections()
img_list <- sits_cube(
  source = "MPC",      # Microsoft Planetary Computer
  collection = "LANDSAT-C2-L2",
  bands = c("RED", "NIR08"),
  roi = roi,           # Region of interest
  start_date = "2010-01-01", end_date = "2025-01-01")
local_cube <- sits_cube_copy(img_list, output_dir)
reg_cube <- sits_regularize(local_cube,
  roi = roi,           # Study area
  period = "P1M",      # by month
  output_dir = output_dir)
```

- Generic interface to any STAC compliant data source protocol;
- List of STAC compliant servers: <https://stacindex.org>;



- Generic interface to any STAC compliant data source protocol;
- List of STAC compliant servers: <https://stacindex.org>;
- Understand the hierarchy:
 - ➊ Catalog
 - ➋ Collection (products)
 - ➌ Asset/Item (raster file, raster stack, or single band)
- Asset URL can be used with GDAL virtual file: `vsicurl`;
- Enables preprocessing, cropping, resampling...;
- Download only finished product.



```
library(rstac)
stac_source <- stac("https://planetarycomputer.microsoft.com/api/
  stac/v1")
all_collections <- collections(stac_source)
stac_query <- stac_search(q = stac_source,
  collections = "usgs-lcmap-conus-v13", # USGS Landcover
  bbox = ao_i_bbox,                    # Study area
  datetime = "2021-01-01/2021-12-31")
assets_download(stac_query,
  "lcpri",                             # One available asset
  output_dir = output_dir)
```

- Requires **downloading in advance**;
- "Swiss army knife" for remote sensing;



- Requires **downloading in advance**;
- "Swiss army knife" for remote sensing;
- Several spatial analysis algorithms:
 - ▶ Calculates any of several dozen spectral indices;
 - ▶ Pan-sharpening;
 - ▶ Cloud masking;
 - ▶ Image classification, (both supervised and unsupervised);
 - ▶ Histogram matching.

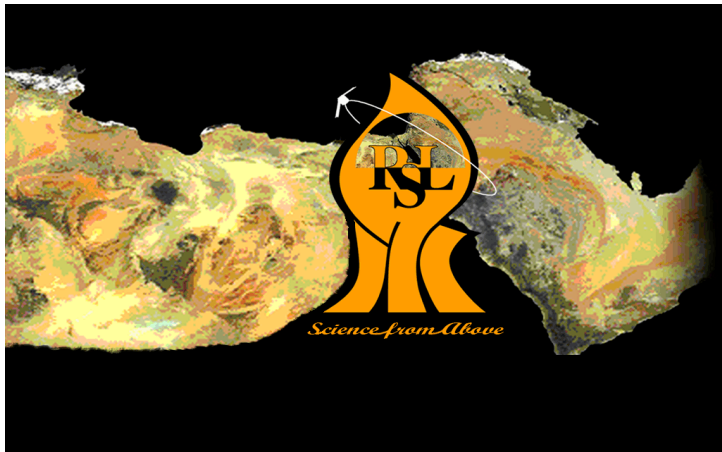


```
library(RStoolbox)
lsat <- stackMeta(mtlFile)      # Read all metadata from MTL file

# Supervised classification
# Using digitized polygons of classes in "train" features
sc <- superClass(lsat, trainData = train,
  responseCol = "class", model = "rf", # Random Forest classifier
  tuneLength = 1, trainPartition = 0.7)

# plotting:
r <- as.factor(sc$map)
levels(r) <- data.frame(ID = 1:4,
  class_supervised = levels(train$class)) # Classes from train data
ggR(r, # ggR function from RStoolbox
  geom_raster = T, forceCat = T) +
  scale_fill_manual(
    values = c("yellow", "sandybrown", "darkgreen", "blue"))
```

Thanks



Thanks,
Questions?