

Big Data, organization and analysis

Evapotranspiration data from Satellite MODIS product

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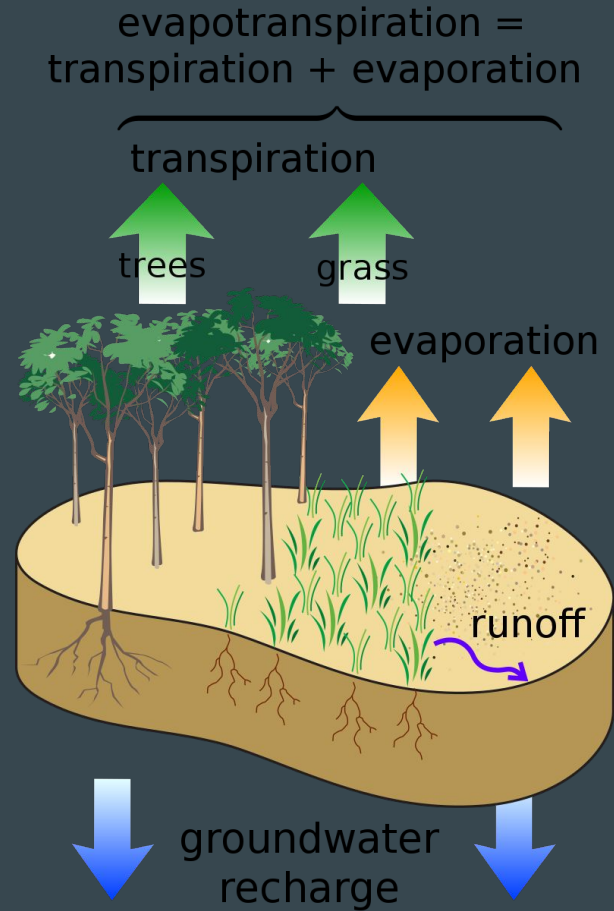
Outline

- Understand what is Evapotranspiration
- Water balance in river basins, Forest photosynthesis
- Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)
- Download the data
- Import the data into Google Colab
- Resample the data
- Plot and compare different watersheds

What is Evapotranspiration?

What is Evapotranspiration?

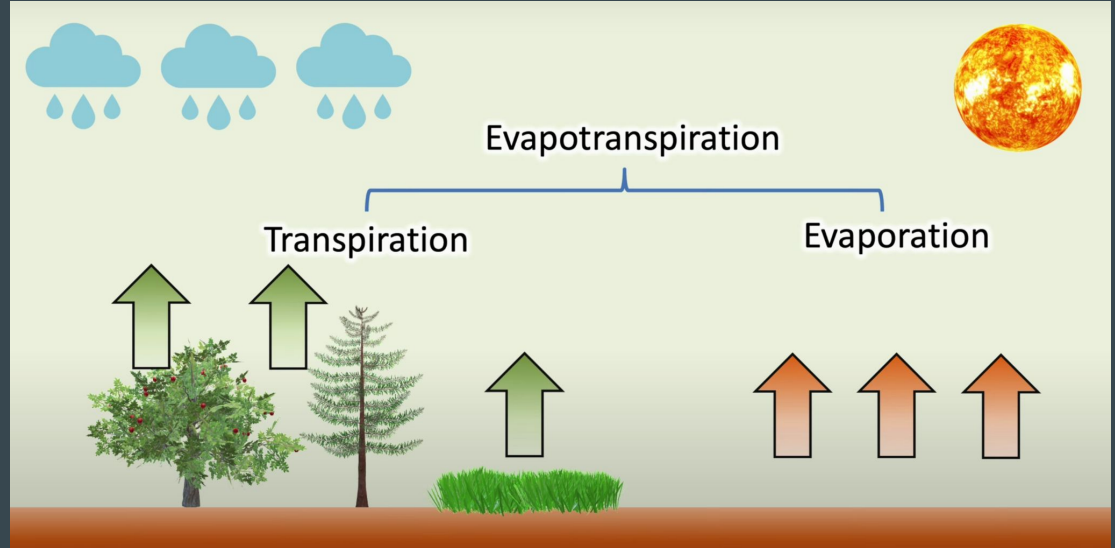
- Transpiration + Evaporation
- Potential x Real evapotranspiration



What is Evapotranspiration?

Forces governing ET:

- Solar radiation
- Water availability in soil/plant
- Water vapor gradient in air
- Water vapor wind transport



Introduction to MODIS Evapotranspiration (MOD16) - a free global dataset of ET & PET
https://www.youtube.com/watch?v=3r_gil0EViw

In **vascular plants**, water exits the plants through the **stomata** in the leaves whereas, in **nonvascular plants** (Bryophytes, Moss and Algae), it exits through the **phyllids**.

https://en.wikipedia.org/wiki/Non-vascular_plant

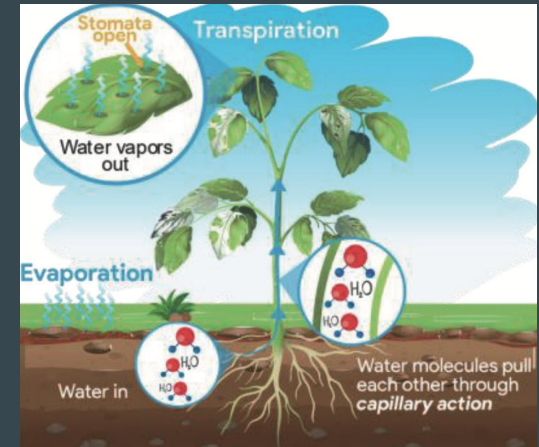
Transpiration in Vascular Plants

- plants retain less than 5% of water absorbed by roots for growth.
→ it goes back to the atmosphere!

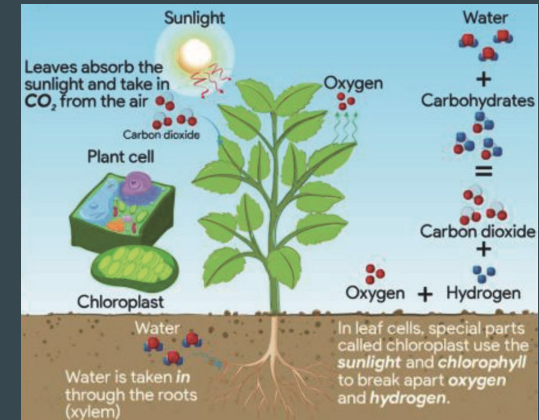
Photosynthesis



- To make sugars, plants must absorb carbon dioxide (CO₂) from the atmosphere through **stomata**.

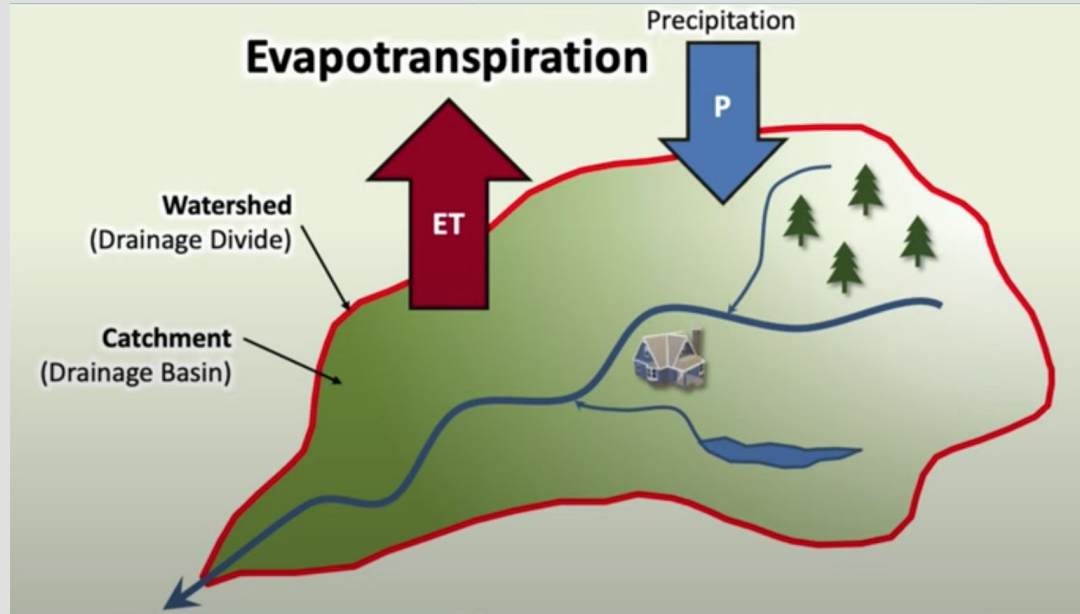


transpiration



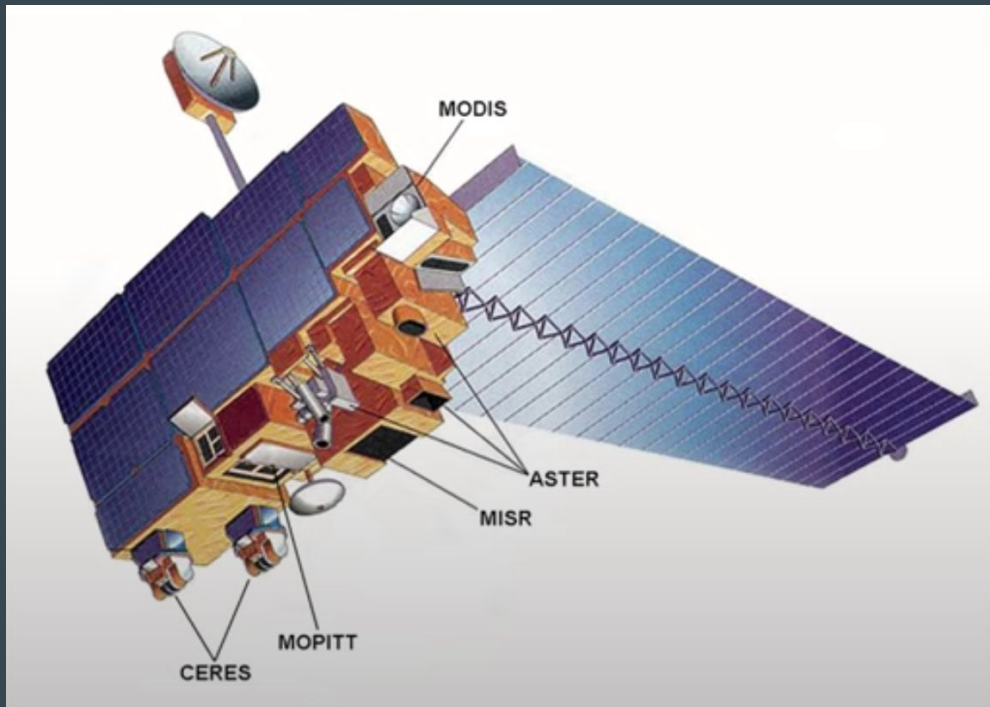
photosynthesis

Water balance in river basins



Introduction to MODIS Evapotranspiration (MOD16) - a free global dataset of ET & PET
https://www.youtube.com/watch?v=3r_6il0EViw

What is MODIS?



- Instrument on board of TERRA & AQUA satellites (NASA)
- TERRA = "MOD"
- AQUA = "MYD"

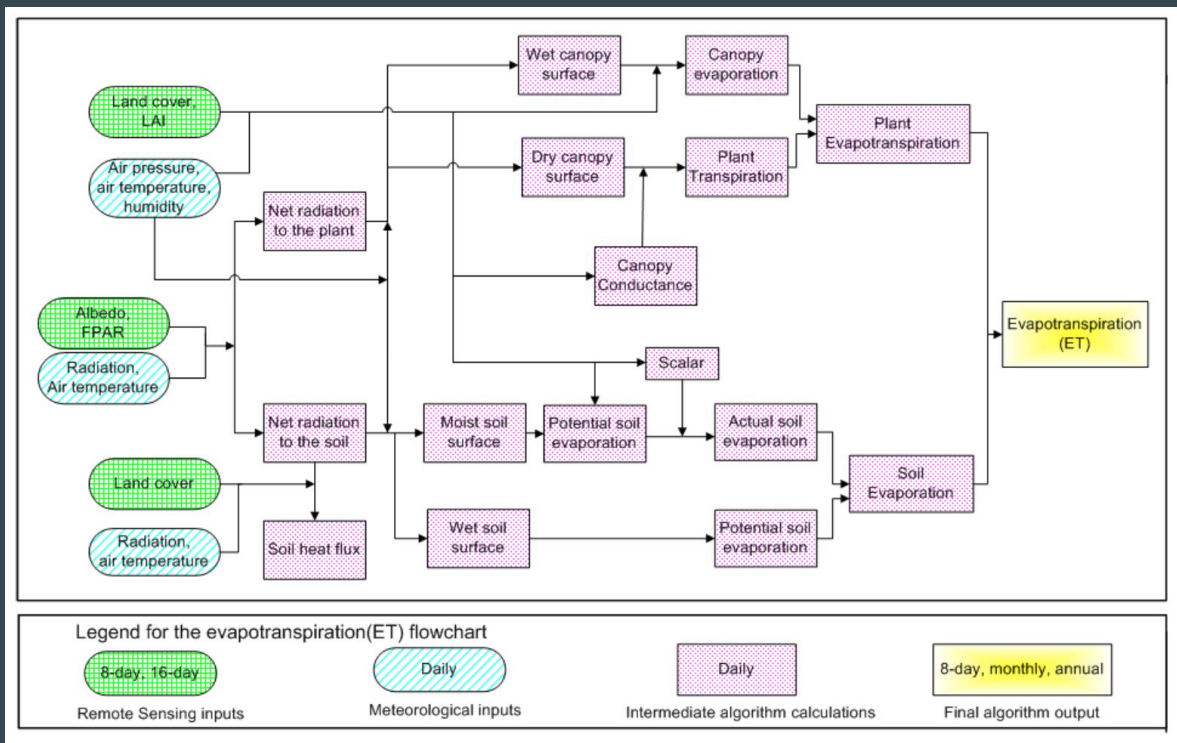
MODIS MOD16 ET Product

- ❖ Evapotranspiration (ET) →
 - Total ET
 - Total PET
- ❖ Latent Heat Flux (LE)
- ❖ Quality control flags

MODIS MOD16 ET Product

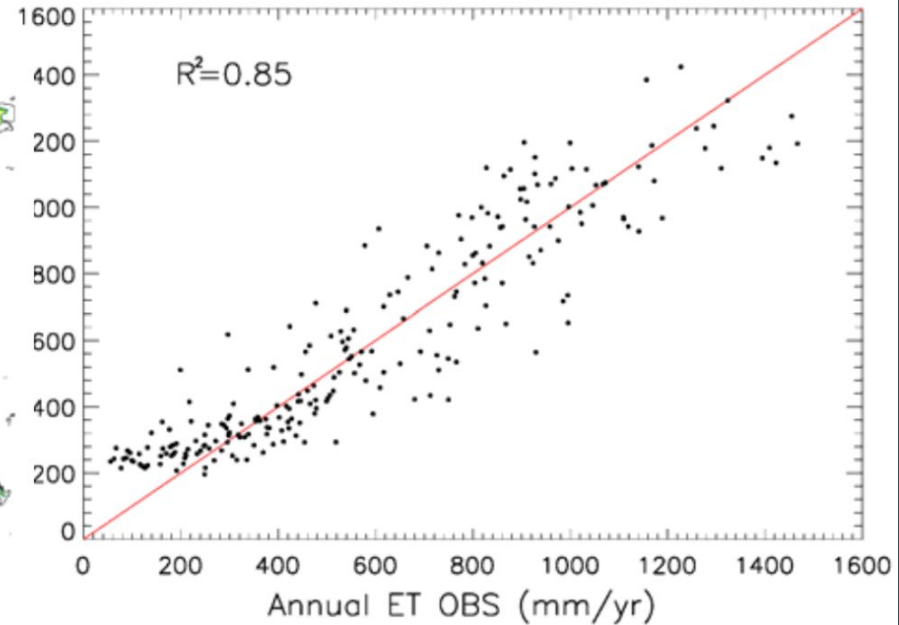
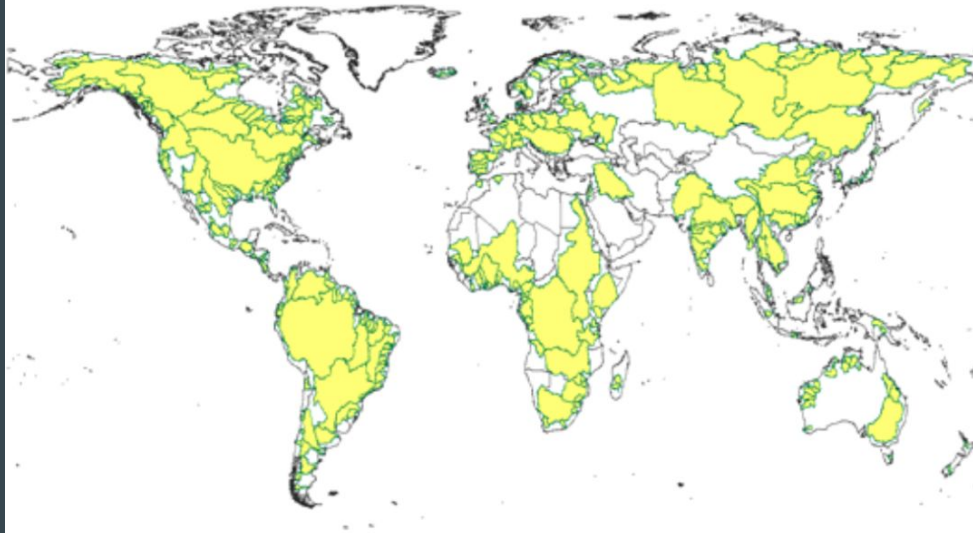
- MODIS ET algorithm follows the Penman-Monteith equation.
- Includes evaporation from wet and moist soil, evaporation from rainwater intercepted by the canopy before it reaches the ground, and the transpiration through stomata on plant leaves and stems
- The MOD16A2/A3 ET products are produced at the 8-day and annual intervals.

Flowchart of the improved MOD16 ET algorithm.



LAI: leaf area index; FPAR: Fraction of Photosynthetically Active Radiation.

Algorithm Performance at Global Watersheds



The MOD16 ET estimates can explain 85% of the variations of the pseudo-ET observations for 232 river basins.

Global evapotranspiration data set

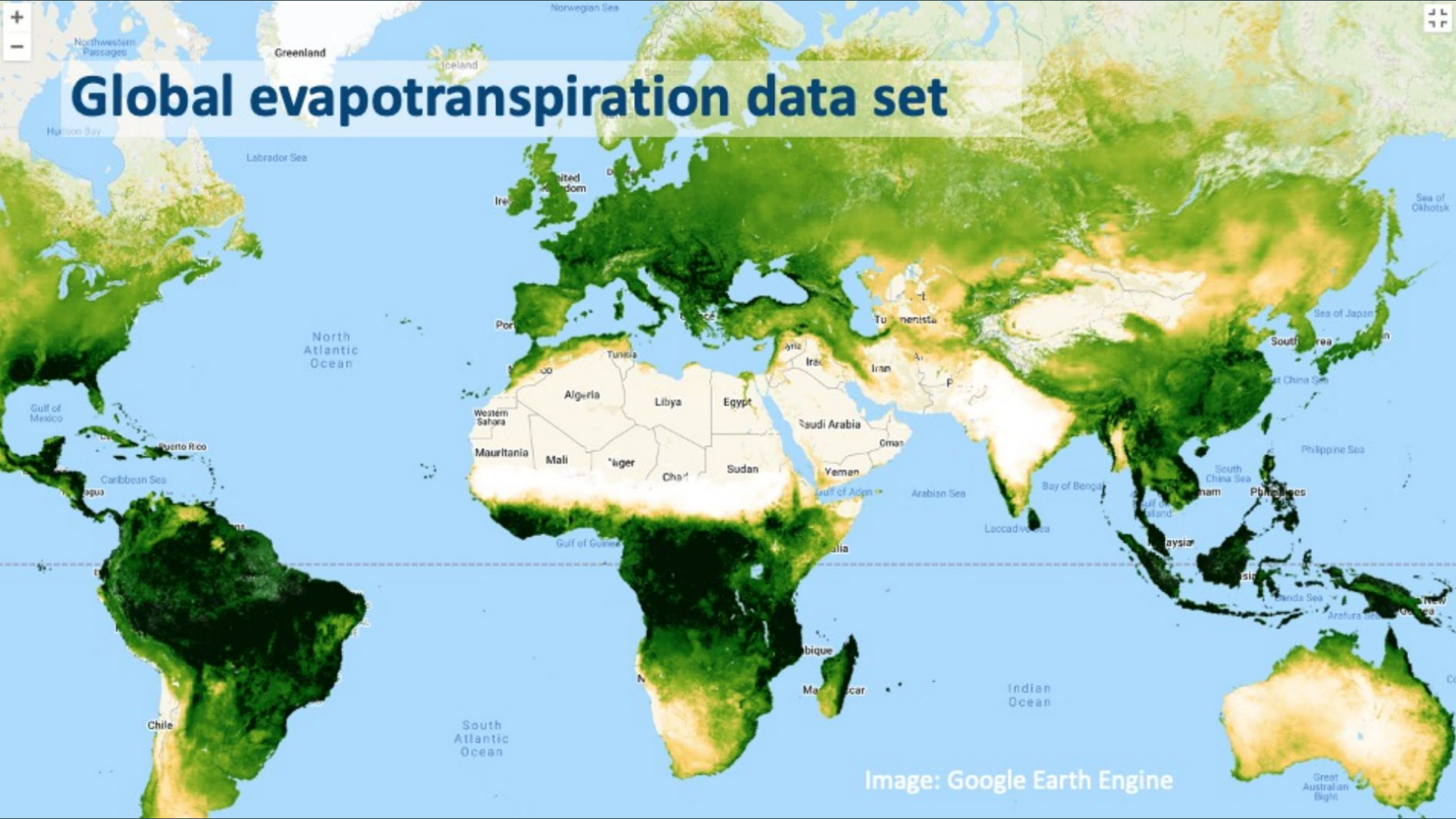


Image: Google Earth Engine

Spatial resolution: 500 x 500 m

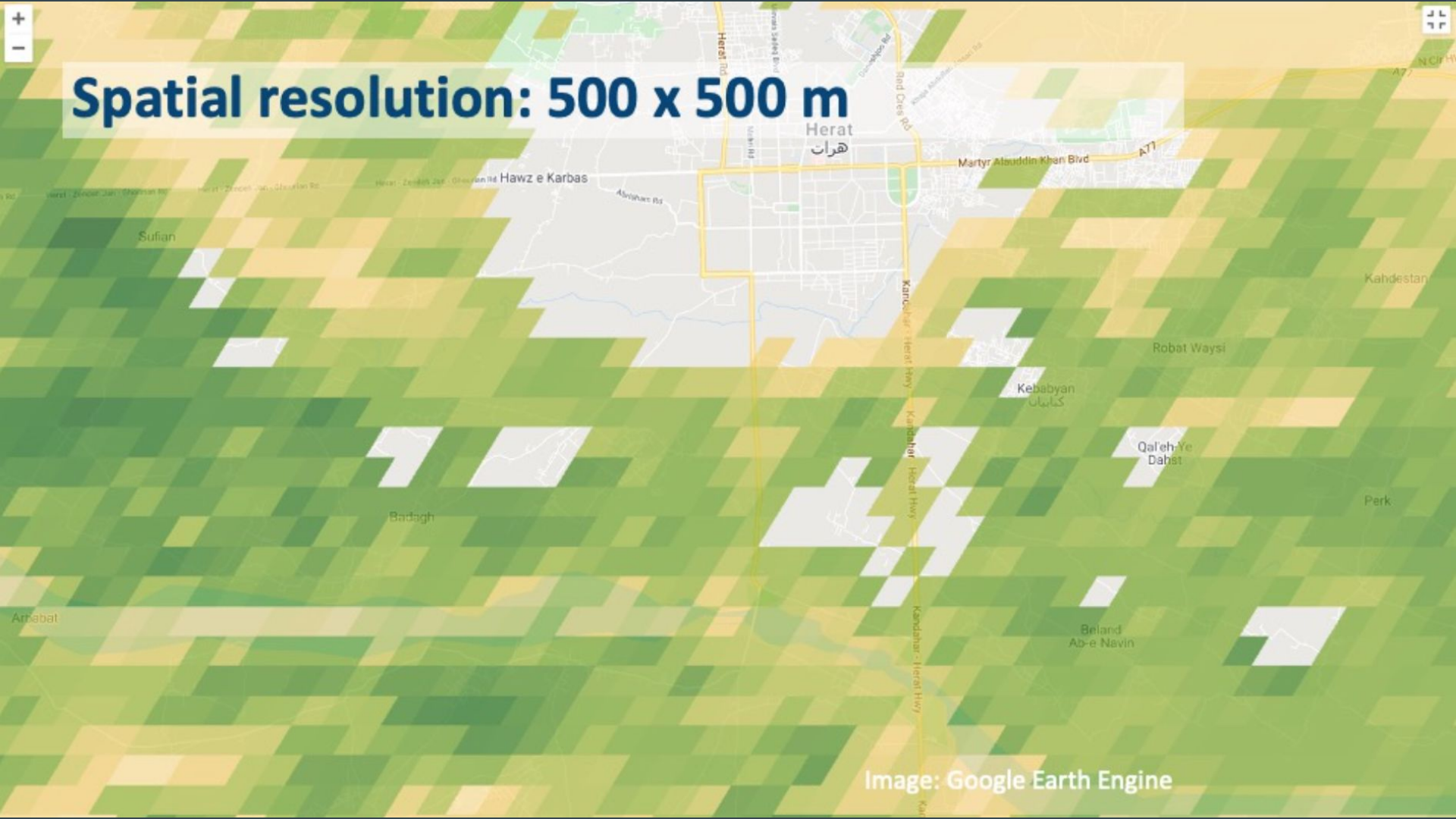
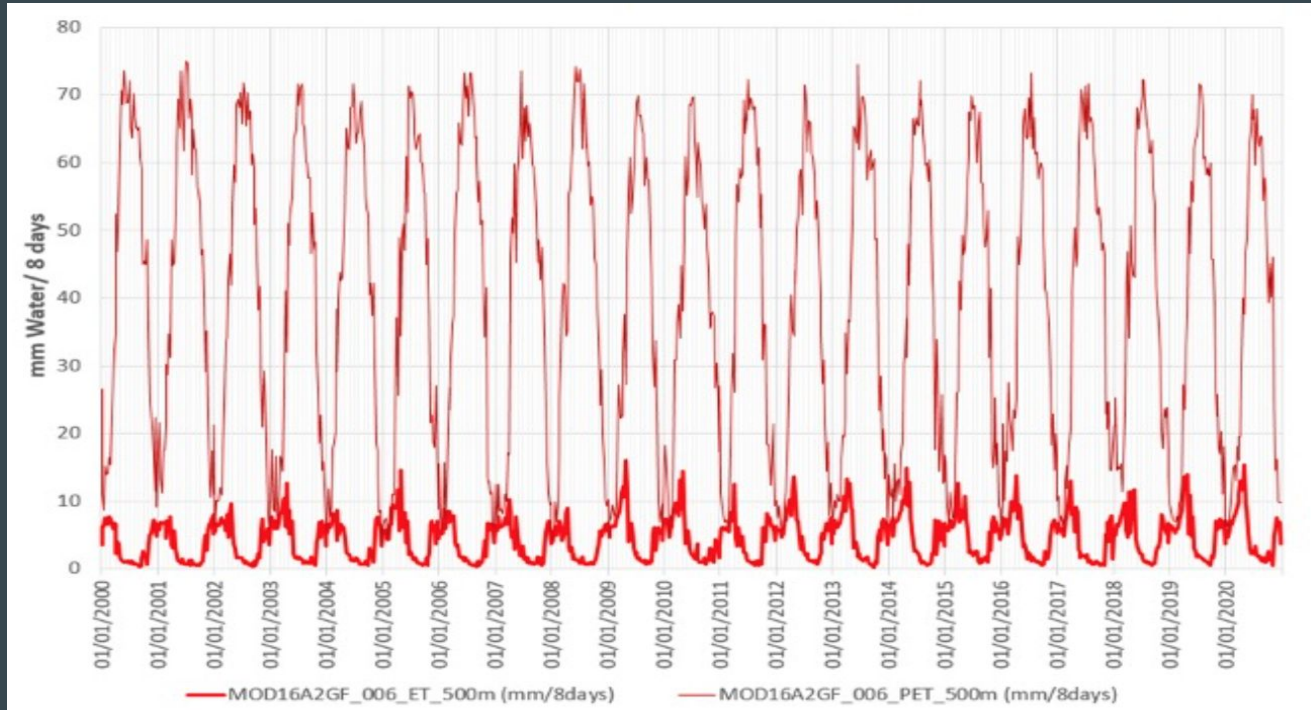
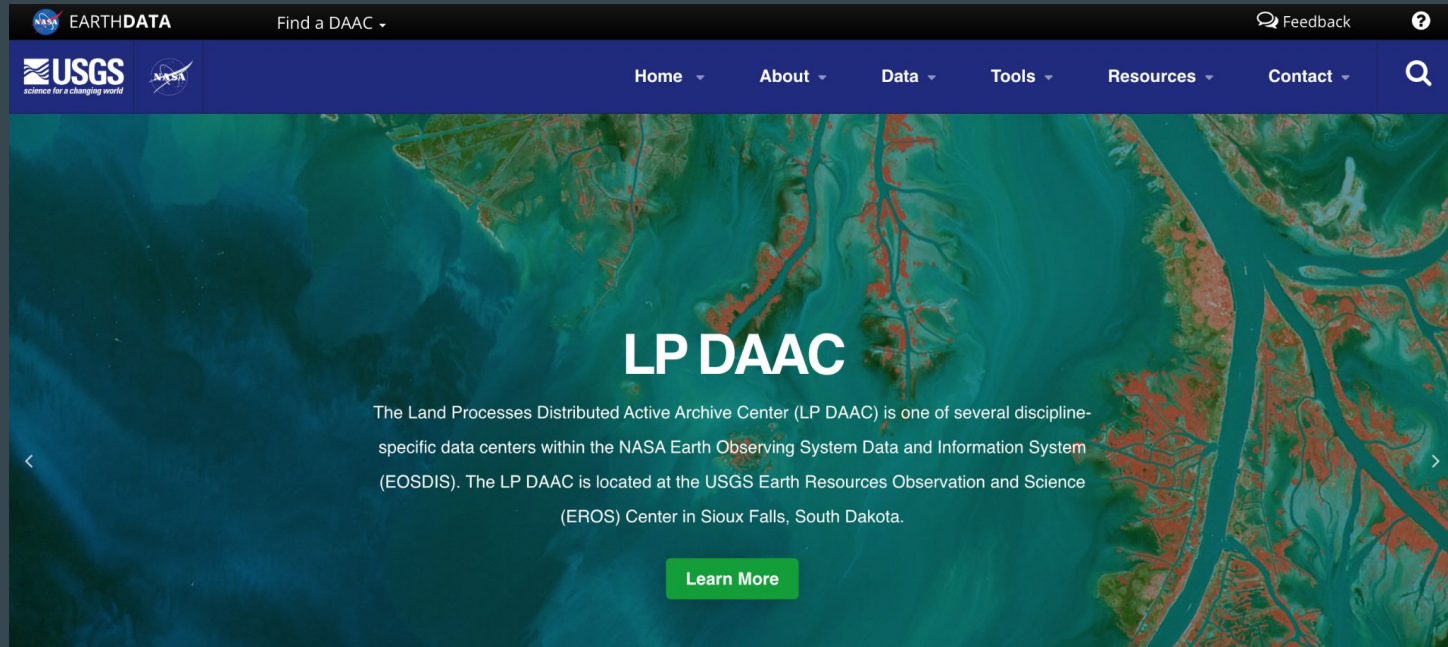


Image: Google Earth Engine

Time series: 01 January 2000 to present (22 years)



Search Data Catalog



The Land Processes Distributed Active Archive Center (LP DAAC) is one of several discipline-specific data centers within the NASA Earth Observing System Data

<https://lpdaac.usgs.gov/>

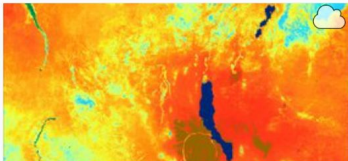
Search Data Catalog

What are you looking for... Search

Cloud Access ▼ Temporal Range ▼ Collection ▼ Version ▼ Keyword ▼ Spatial Resolution ➤

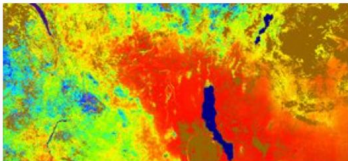
KEYWORD: EVAPOTRANSPIRATION (ET) × **SPATIAL RESOLUTION (M): 500.0** × **STATUS: OPERATIONAL** × [Clear filters](#)

Showing 1 - 14 of 14 results Cards List



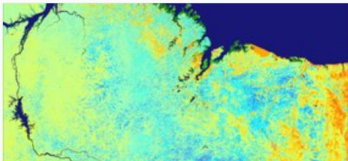
MOD16A2 v061
MODIS/Terra Net Evapotranspiration 8-Day L4 Global 500 m SIN Grid

TERRA MODIS EVAPOTRANSPIRATION (ET)



MOD16A2 v006
MODIS/Terra Net Evapotranspiration 8-Day L4 Global 500 m SIN Grid

TERRA MODIS EVAPOTRANSPIRATION (ET)



MOD16A2GF v061
MODIS/Terra Net Evapotranspiration Gap-Filled 8-Day L4 Global 500 m SIN Grid

TERRA MODIS EVAPOTRANSPIRATION (ET)

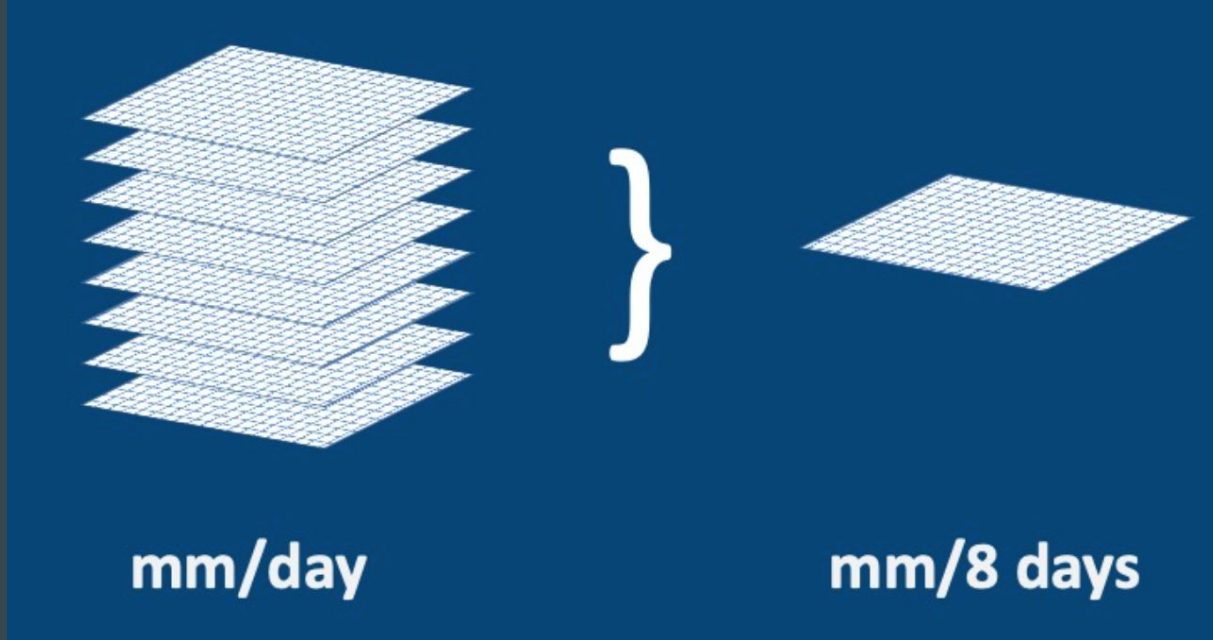
MOD16A2.* and MOD16A2GF.* files

<https://lpdaac.usgs.gov/>

MODIS MOD16A2GF Version 6

- Global ET & PET dataset
- Spatial resolution: 500 m x 500 m
- Time series: January 2000 - 2022 (22 anos)
- Time steps: 8-day composite

8-day composite



AppEEARS - sign in!



Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)

<https://appeears.earthdatacloud.nasa.gov/>

AppEEARS - Downloading the ET data

- Access the GitHub of the class:
<https://github.com/stenoe/BDOA>
- Download 3 Shapefiles (perimeter of the water basins)
 - Nhundiaquara river (Paraná - Brazil)
 - Ahja river (Estonia)
 - Salma river (Afghanistan)
- Download the 3 zip files!

Access AppEEARS - Downloading the ET data

- Extract -> Area -> Start a new request
 - Enter a name to identify your sample: **Nhundiaquara**
 - Drop a vector polygon: **nhundiaquara.zip**
 - Select the layer: **MOD16A2GF**

The screenshot displays the AppEEARS web interface with a blue header bar containing the NASA logo, the text 'AppEEARS', and navigation links for 'Extract', 'Explore', and 'Help'. A user profile icon and name 'emiliomercuri' are visible on the right. The main content area is divided into two columns. The left column, titled 'Upload a file or draw a polygon using the [house] or [square] icon', contains instructions to drop a vector polygon file, a link to click here to select the file, and supported file formats: Shapefile (.zip including .shp, .dbf, .prj, and .shx files) and GeoJSON (.json or .geojson). Below this are date selection fields for 'Start Date' (01-01-2000) and 'End Date' (01-01-2023), with a checkbox for 'Is Date Recurring?'. The right column, titled 'Selected file (bacia_estacao84)', shows a satellite map with a green polygon overlay. Below the map is a text box with coordinates 'Lat: -25.602 Lon: -48.645' and a note: 'To clear a polygon, draw a new polygon or upload a vector polygon file.' At the bottom, the 'Select the layers to include in the sample' section shows a list of layers with 'Terra MODIS Net Evapotranspiration Gap-Filled (ET & LE) MOD16A2GF.006, 500m, 8 day, (2000-01-01 to Present)' selected. The 'Selected layers' section on the right shows 'ET_500m' and 'PET_500m' both set to '500m, 8 day'.

AppEEARS Extract Explore Help emiliomercuri

Upload a file or draw a polygon using the or icon

Drop a vector polygon file containing the area feature(s) to extract or [click here](#) to select the file.

Supported file formats:

- Shapefile (.zip including .shp, .dbf, .prj, and .shx files)
- GeoJSON (.json or .geojson)

Start Date: 01-01-2000 End Date: 01-01-2023

☐ Is Date Recurring?

Select the layers to include in the sample

Terra MODIS Net Evapotranspiration Gap-Filled (ET & LE) MOD16A2GF.006, 500m, 8 day, (2000-01-01 to Present)

ET_QC_500m

Selected file (bacia_estacao84)

Lat: -25.602 Lon: -48.645

To clear a polygon, draw a new polygon or upload a vector polygon file.

Selected layers

| | |
|----------|-------------|
| ET_500m | 500m, 8 day |
| PET_500m | 500m, 8 day |

AppEARS - data from Estonia, Afghanistan and Brazil

The screenshot displays the AppEARS web interface. At the top, there's a NASA EarthData logo and navigation links for 'Extract', 'Explore', and 'Help'. A user profile 'emiliomercuri' is logged in. A blue banner at the top contains a message: 'Some MODIS/Terra Snow Cover v6.1 (MOD10A2) tiles are currently unavailable to AppEARS. Requests containing MOD10A2 data may result in processing errors.' Below this, the 'Explore Requests' section shows a list of requests. The first two requests are 'Nhundiaquara' and 'Ahja watershed MOD16 ET & PET', both with 'Area Sample' type and 'In Progress' status. The next three are 'Temperatura_Kalli', 'Reola watershed MOD16 ET & PET', and 'Kalli watershed MOD16 ET & PET', all with 'Area Sample' type and 'Expired' status. Each request row includes a progress bar, a details icon, and a date submitted/completed. Action icons for each row include a chart, download, delete, and a refresh icon for expired requests.

Some MODIS/Terra Snow Cover v6.1 (MOD10A2) tiles are currently unavailable to AppEARS. Requests containing MOD10A2 data may result in processing errors.

Explore Requests

Please see [Sample Request Retention](#) for details on expired requests.


Showing requests 1 - 17 of 17

« Prev 1 Next »



| Request | Type | Status | Details | Date Submitted | Date Completed |
|--------------------------------|-------------|----------------------------|-------------------|---------------------------------|--|
| Nhundiaquara | Area Sample | <div><div></div></div> 99% | i | 03-10-2023 3:54:45 PM GMT-3 | Chart Download Delete |
| Ahja watershed MOD16 ET & PET | Area Sample | <div><div></div></div> 45% | i | 03-10-2023 3:50:05 PM GMT-3 | Chart Download Delete |
| Temperatura_Kalli | Area Sample | Expired | i | 01-19-2023 11:31:58 AM GMT-3 | 01-19-2023 12:48:25 PM GMT-3 Chart Download Delete Refresh |
| Reola watershed MOD16 ET & PET | Area Sample | Expired | i | 01-11-2023 11:32:41 AM GMT-3 | 01-11-2023 5:13:17 PM GMT-3 Chart Download Delete Refresh |
| Kalli watershed MOD16 ET & PET | Area Sample | Expired | i | 01-11-2023 9:36:47 AM GMT-3 | 01-11-2023 10:20:39 AM GMT-3 Chart Download Delete Refresh |

Application for Extracting and Exploring Analysis Ready Samples (AppEARS) =
<https://appears.earthdatacloud.nasa.gov/>

Download the data

 AppEEARS








Extract ▾ Explore Help ▾

  emiliomercuri ▾


Download Area Sample

Request: Nhundiaquara >

Supporting Files

| | | |
|--|---|-----------|
|  Nhundiaquara-MOD16A2GF-006-metadata.xml | ISO 19115 Metadata | 21.64 KB |
|  Nhundiaquara-granule-list.txt | URLs for all source data used in the extraction | 111.68 KB |
|  README.md | Instructions and details about the request | 24.47 KB |
|  Nhundiaquara-request.json | JSON file which can be used to create a new request | 128.16 KB |
|  MOD16A2GF-006-ET-QC-500m-Statistics-QA.csv | Statistics for quality layers | 90.84 KB |
|  MOD16A2GF-006-ET-QC-500m-lookup.csv | Lookup values for the quality bits | 2.29 KB |
|  MOD16A2GF-006-Statistics.csv | Statistics for layers | 309.03 KB |

0 Selected Download ▾

| <input type="checkbox"/> | Name ↑↓ | Size ↑↓ |
|--------------------------|--|---------|
| <input type="checkbox"/> |  MOD16A2GF006_500m_aid0001.nc | 4.84 MB |

1 - 1 displayed, 1 in total

Download the data - File formats, projections

- QGIS - Shapefile preparation -> zipfile
- **Data formats:**
 - NetCDF (Network Common Data Form) version 4
 - GeoTIFF
 - CSV file (MOD16A2GF-006-Statistics.csv) - We will only use this one!
 - ET and PET comes in $\text{kg/m}^2/8\text{-day} = \text{mm}/8\text{-day}$
- **Projection:**
 - Geographic
 - Datum: WGS84

Thanks! Let's code!

Google Colab

What we will do:

- Import the data into COLAB
- Process it to daily data
- Compare ET from Afghanistan Brazil and Estonia

