

# TEA018 - Hidrologia Ambiental

Dados de evapotranspiração de satélite - MODIS/NASA

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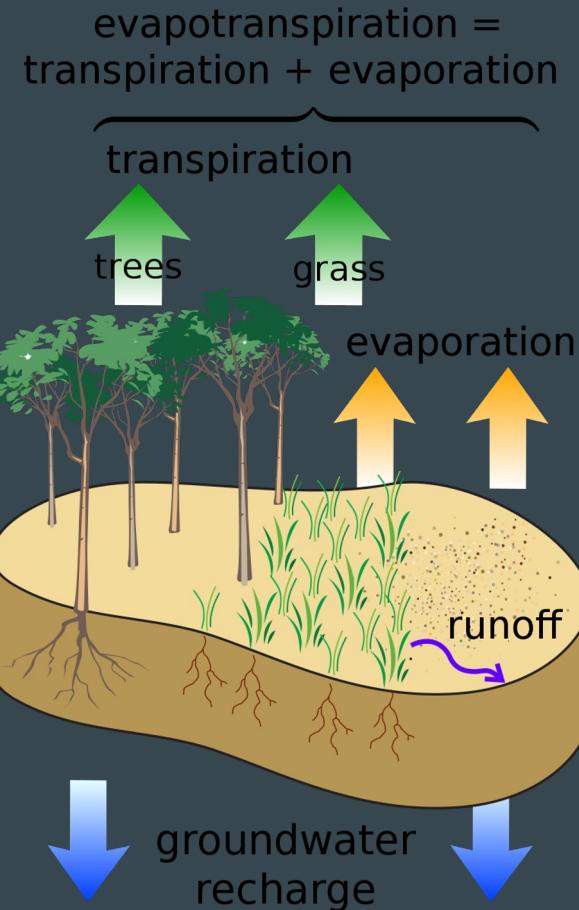
# Agenda

- O que é Evapotranspiração?
- Balanço hídrico em bacias hidrográficas, Fotossíntese florestal
- Aplicativo de extração e exploração de amostras para análise (AρρEEARS)
- Baixe os dados
- Importe os dados para o Google Colab
- Reamostrar os dados
- Trace e compare diferentes bacias hidrográficas

# O que é Evapotranspiração?

# O que é Evapotranspiração?

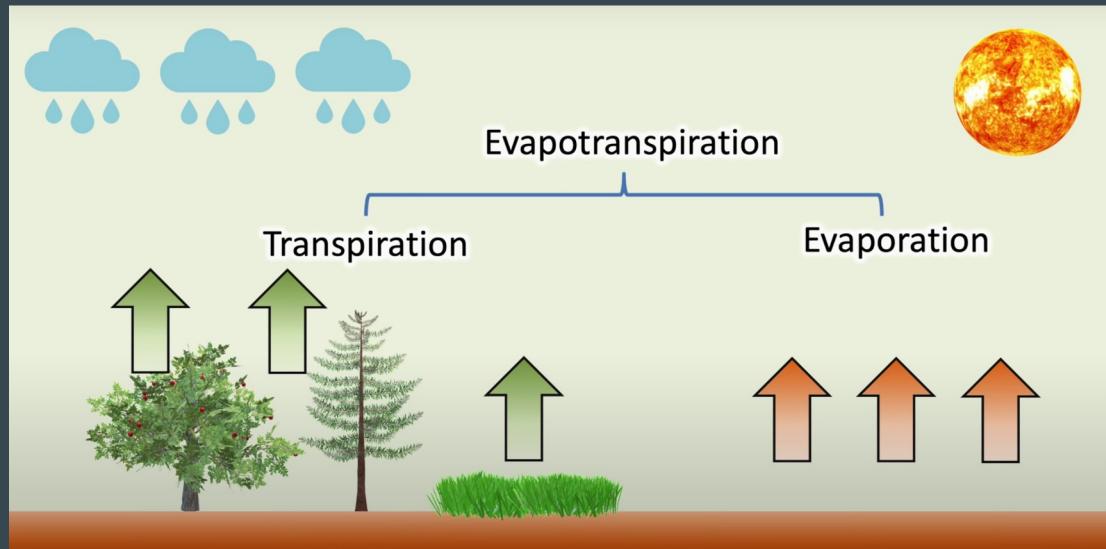
- Transpiração + Evaporação
- Evapotranspiração potencial real



# 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\\_6il0EViw](https://www.youtube.com/watch?v=3r_6il0EViw)

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**.

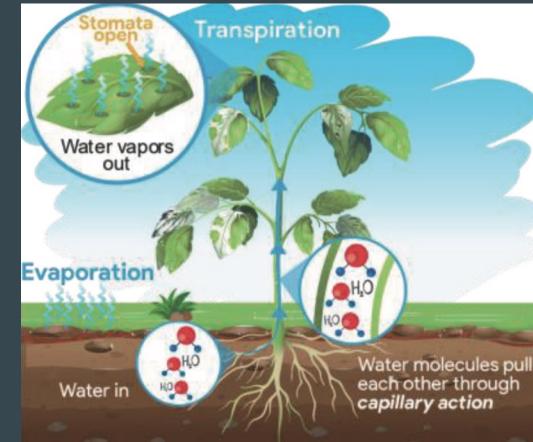
[https://en.wikipedia.org/wiki/Non-vascular\\_plant](https://en.wikipedia.org/wiki/Non-vascular_plant)

# Transpiration in Vascular Plants

- plants retain less than 5% of water absorbed by roots for growth.



it goes back to the atmosphere!

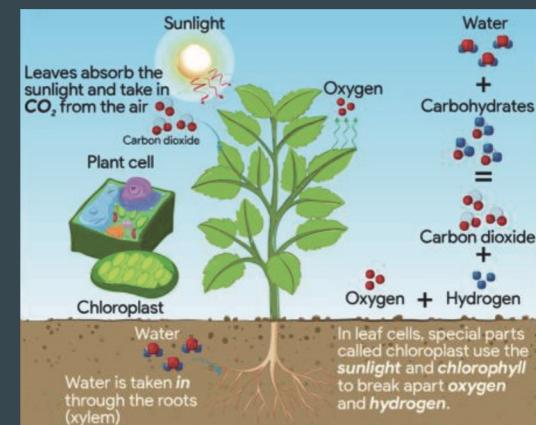


transpiration

## Photosynthesis

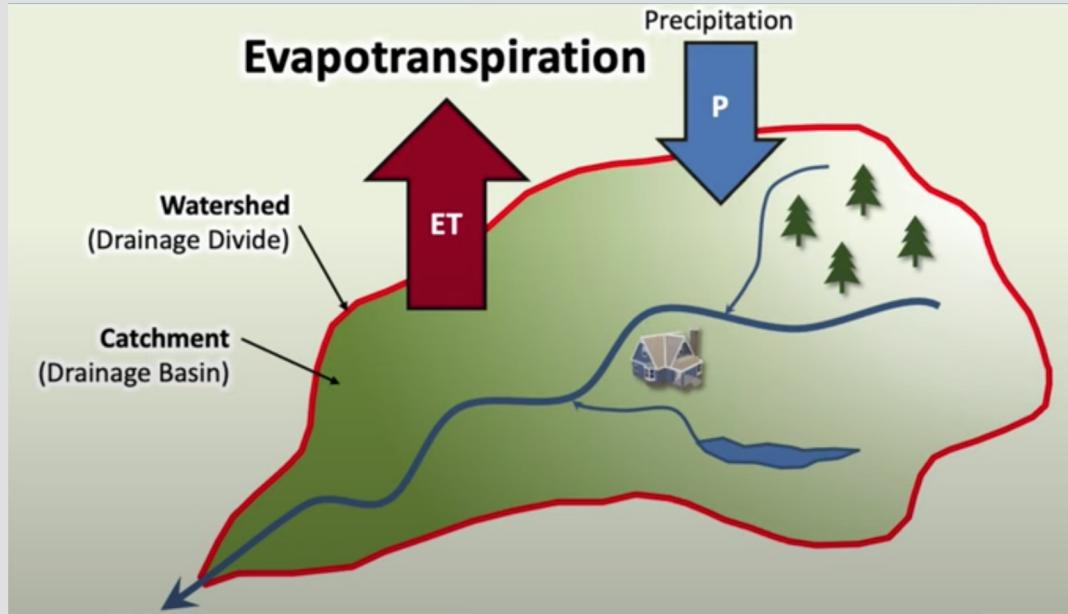


- To make sugars, plants must absorb carbon dioxide (CO<sub>2</sub>) from the atmosphere through **stomata**.



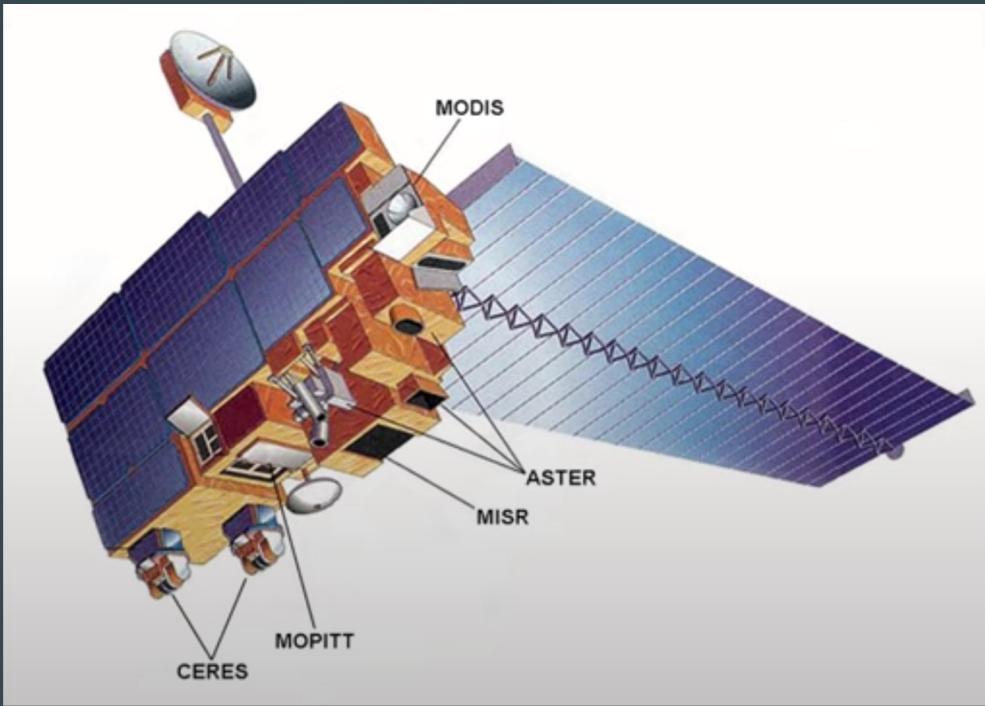
photosynthesis

# 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](https://www.youtube.com/watch?v=3r_6il0EViw)

# What is MODIS?



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

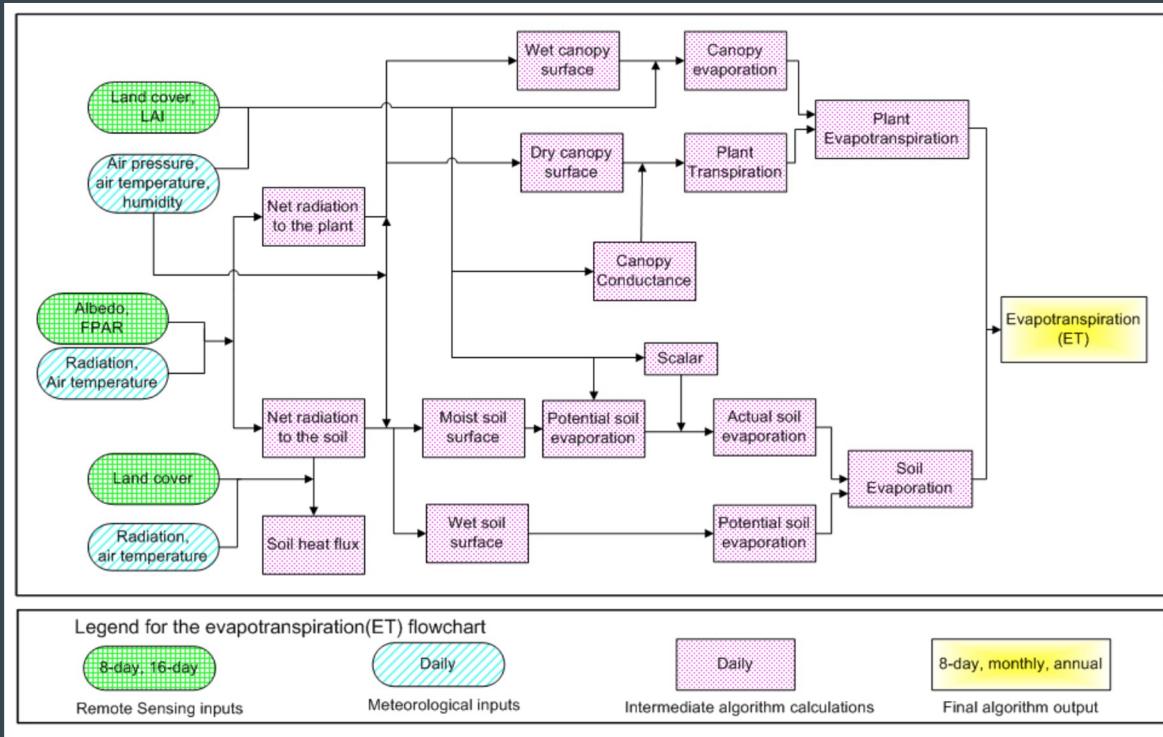
# MODIS MOD16 ET Product

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

# MODIS MOD16 ET Product

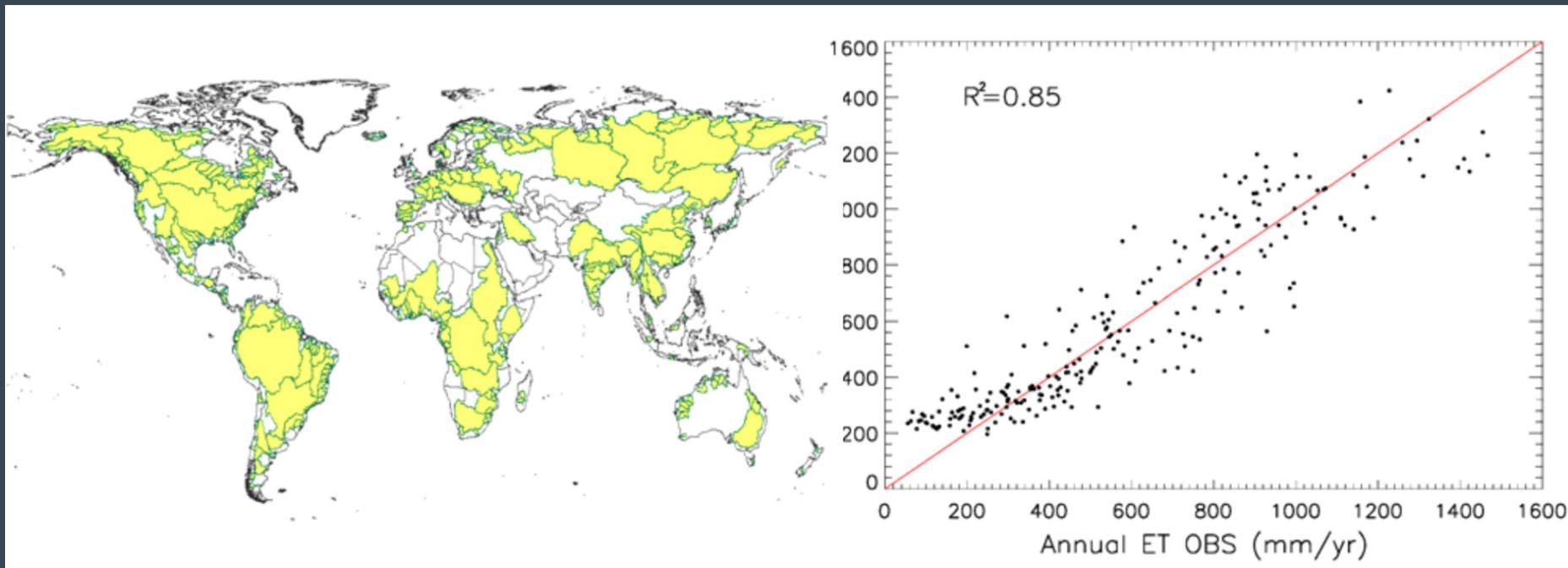
- MODIS ET algorithm follows the Penman-Monteith equation.
- Includes evaporation from wet and moist soil, evaporation from rainwater intercepted by the canopy before it reaches the ground, and the transpiration through stomata on plant leaves and stems
- The MOD16A2/A3 ET products are produced at the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

# Flowchart of the improved MOD16 ET algorithm.



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

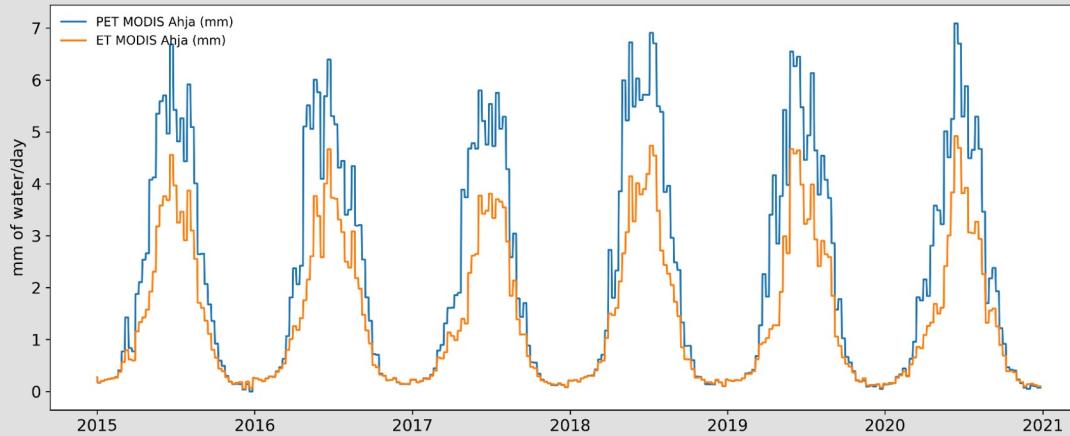
# Algorithm Performance at Global Watersheds



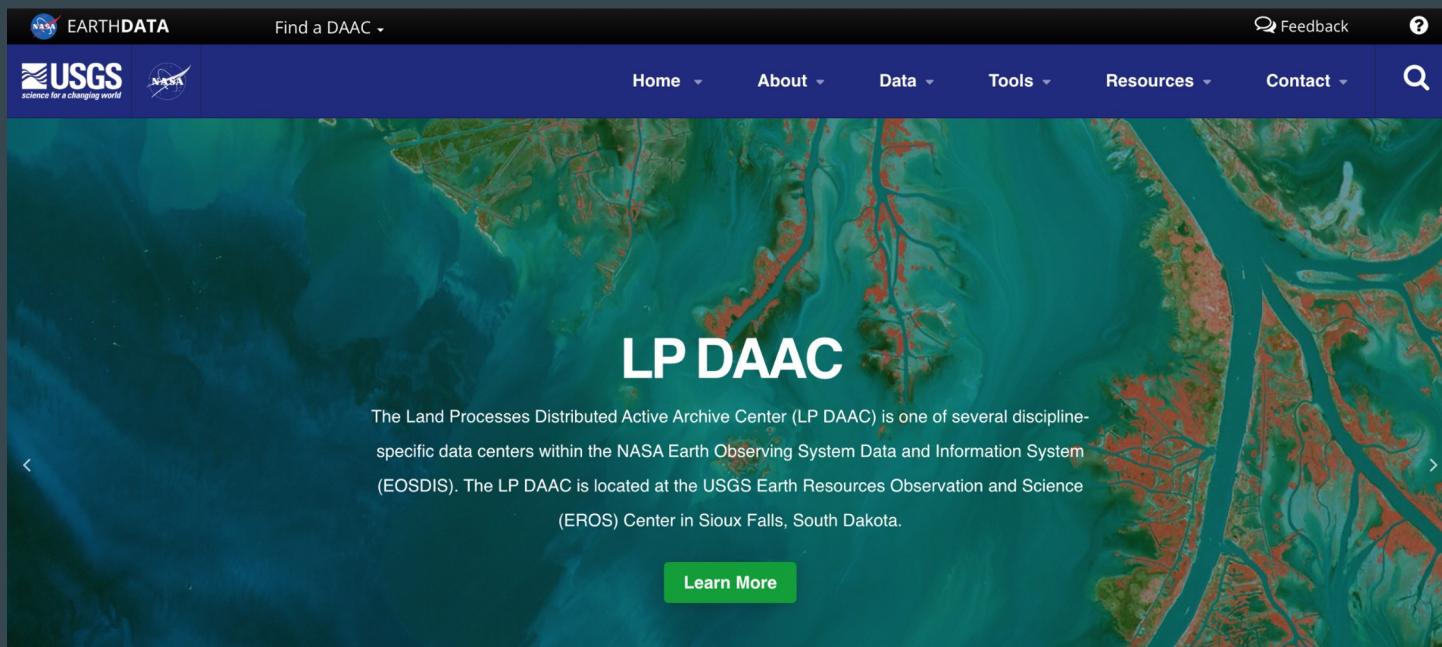
The MOD16 ET estimates can explain 85% of the variations of the pseudo-ET observations for 232 river basins.

# Time series: 2000 ...

- Global evapotranspiration data set
- Spatial resolution: 500 x 500 m
- View some ET and PET data from Ahja river basin, Estonia



# 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 and Information System (EOSDIS). The LP DAAC is located at the USGS Earth Resources Observation and Science (EROS) Center in Sioux Falls, South Dakota.

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

# Search Data Catalog

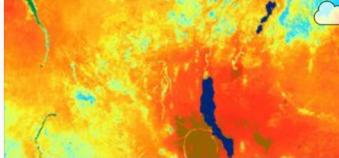
Search

Cloud Access ▾ Temporal Range ▾ Collection ▾ Version ▾ Keyword ▾ Spatial Resolution ▾

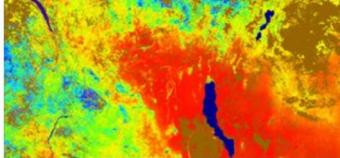
KEYWORD: EVAPOTRANSPIRATION (ET) x SPATIAL RESOLUTION (M): 500.0 x STATUS: OPERATIONAL x [Clear filters](#)

Showing 1 - 14 of 14 results

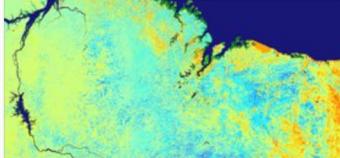
Cards List



**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 \(ET\)](#)



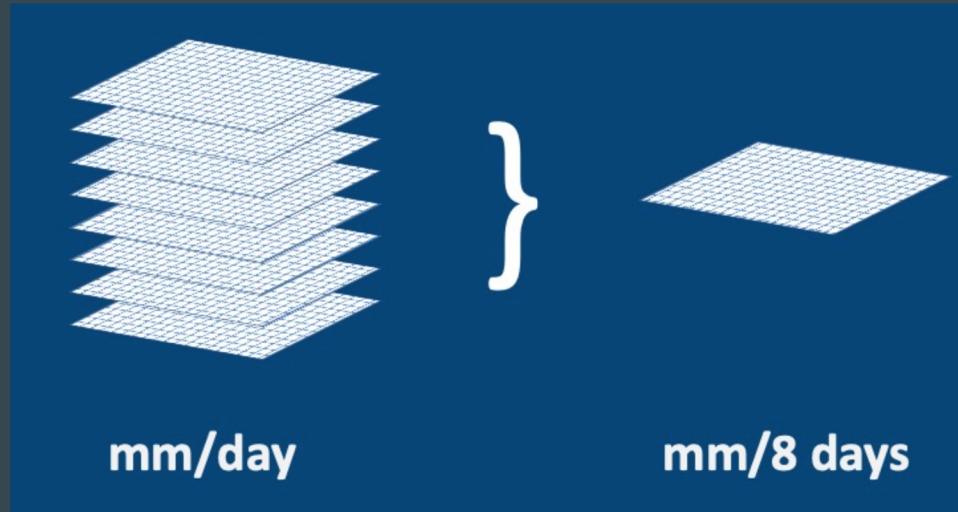
**MOD16A2GF v061**  
MODIS/Terra Net Evapotranspiration Gap-Filled 8-Day L4 Global 500 m SIN Grid  
[TERRA MODIS](#) [EVAPOTRANSPIRATION \(ET\)](#)

MOD16A2.\* and MOD16A2GF.\* files  
<https://lpdaac.usgs.gov/>

# MODIS MOD16A2GF Version 061

- Global ET & PET dataset
- Spatial resolution: 500 m x 500 m
- Time series: January 2000 - present
- Time steps: 8-day composite

# 8-day composite



Source: Introduction to MODIS Evapotranspiration (MOD16) - a free global dataset of ET & PET  
[https://www.youtube.com/watch?v=3r\\_6il0EViw](https://www.youtube.com/watch?v=3r_6il0EViw)

# AppEEARS - sign in!

The screenshot shows the AppEEARS application interface. At the top, there is a header bar with the NASA Earthdata logo, a "Other DAACs" dropdown, and a "Sign In" button. Below the header is a navigation bar with links for "Extract", "Explore", and "Help". A message box displays a warning about unavailable MODIS/Terra Snow Cover v6.1 tiles. The main content area features a large "Welcome to AppEEARS!" heading and a description of the application's purpose. A detailed paragraph explains the service's capabilities, mentioning point samples and area samples. The bottom right corner of the main content area contains the "EARTHDATA" logo.

NASA EARTHDATA Other DAACs ▾

AppEEARS Extract Explore Help ▾ Sign In

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

# Welcome to AppEEARS!

**Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)**

The Application for Extracting and Exploring Analysis Ready Samples (**AppEEARS**) offers a simple and efficient way to access and transform geospatial data from a variety of federal data archives. AppEEARS enables users to subset **geospatial datasets** using spatial, temporal, and band/layer parameters. Two types of sample requests are available: **point samples** for geographic coordinates and **area samples** for spatial areas via vector polygons. Sample requests submitted to AppEEARS provide users not only with data values, but also associated quality data values. Interactive visualizations with summary statistics are provided for each sample within the application, which allow users to preview and interact with their samples before downloading their data. Get started with a sample request using the Extract option above, or visit the **Help page** to learn more.

EARTHDATA

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

# AppEEARS - Downloading the ET data

- Access the GitHub of the class:

<https://github.com/emiliomercuri/hidrologia/>

Download 3 Shapefiles (perimeter of the water basins)

- Nhundiaquara river (Paraná - Brazil)
- Ahja river (Estonia)
- Salma river (Afghanistan)

- Download the 3 zip files!
- Use the shapefile from your watershed

# Access AppEEARS - Downloading the ET data

- Extract -> Area -> Start a new request
  - Enter a name to identify your sample: Purus
  - Drop a vector polygon: **shapefile.zip** (Gerado na aula 2 - Colab **2024\_03\_01\_Atividade\_em\_aula\_delineamento.ipynb**)
  - Select the layer: **MOD16A2GF.061**

The screenshot shows the AppEEARS web application interface. At the top, there's a navigation bar with the NASA logo, 'AppEEARS', 'Extract', 'Explore', 'Help', and a user profile icon for 'emiliomercuri'. Below the navigation bar, there's a section for uploading a file or drawing a polygon. A dashed blue box highlights the area where a vector polygon file can be dropped or selected. It also lists supported file formats: Shapefile (.zip including .shp, .dbf, .prj, and .shx files) and GeoJSON (json or geojson). Below this, there are date selection fields for 'Start Date' (01-01-2000) and 'End Date' (01-01-2023), and a checkbox for 'Is Date Recurring?'. To the right, a map displays a green polygon labeled 'bacia\_estacao84' over a satellite image of a landscape. The map includes zoom controls (+, -, home, info, and a NASA logo). Below the map, it says 'Lat: -25.602 Lon: -48.645'. At the bottom left, there's a section for 'Select the layers to include in the sample' with a dropdown menu showing 'Terra MODIS Net Evapotranspiration Gap-Filled (ET & LE)' and 'MOD16A2GF.006, 500m, 8 day, (2000-01-01 to Present)'. At the bottom right, there's a 'Selected layers' section showing two items: 'ET\_500m' and 'PET\_500m', both listed as '500m, 8 day'.

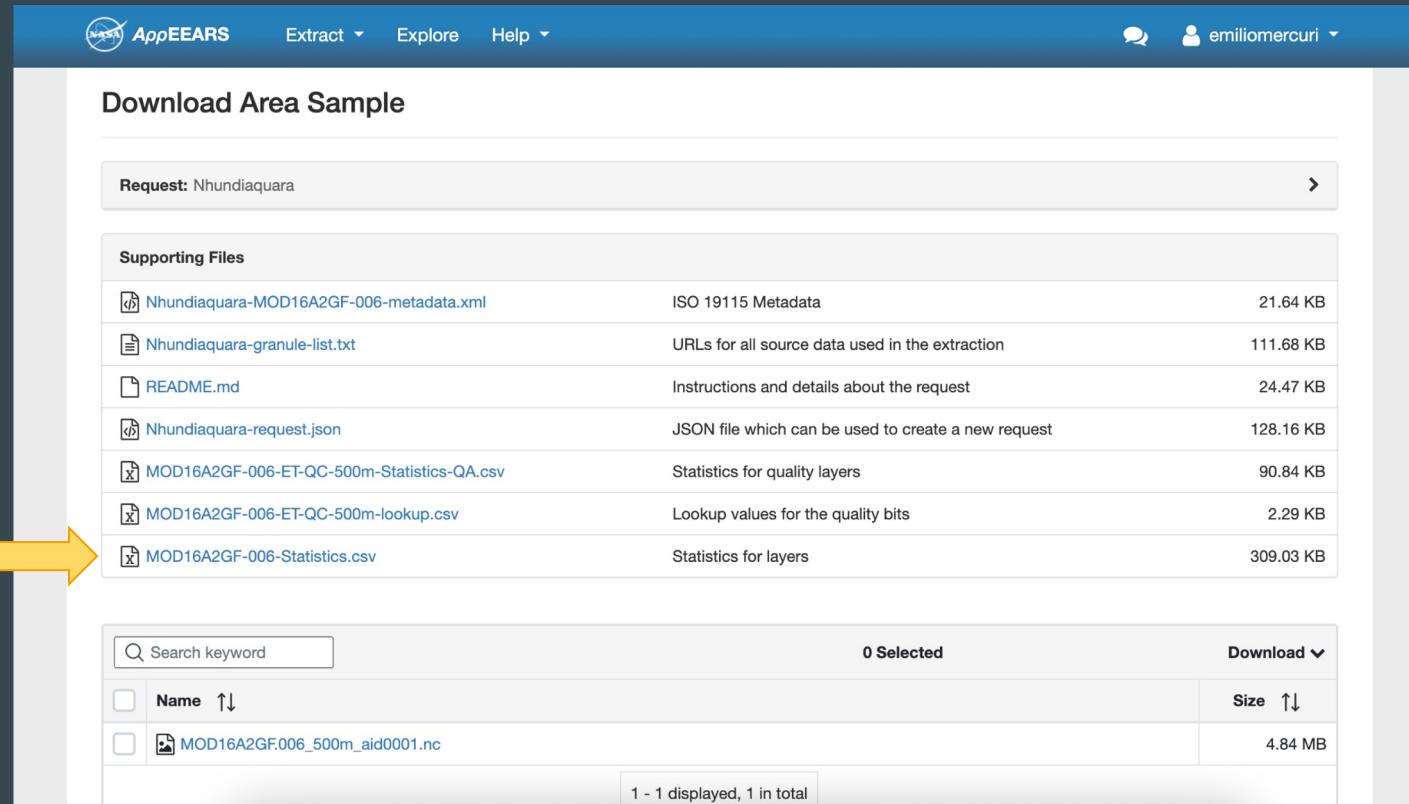
# AppEEARS - data from Estonia, Afghanistan and Brazil

The screenshot shows the AppEEARS application interface. At the top, there is a header bar with the NASA Earthdata logo, a dropdown menu for "Other DAACs", the AppEEARS logo, and navigation links for "Extract", "Explore", and "Help". A user profile for "emilioromerci" is also visible. Below the header, a message box indicates that some MODIS/Terra Snow Cover v6.1 (MOD10A2) tiles are unavailable. The main content area is titled "Explore Requests" and displays a table of 17 requests. The table columns are: Request, Type, Status, Details, Date Submitted, and Date Completed. Each row contains a set of buttons for managing the request. The requests listed are:

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

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

# Download the data



The screenshot shows the AppEEARS interface with the following elements:

- Header:** NASA logo, AppEEARS, Extract ▾, Explore, Help ▾, Chat icon, User icon, emiliomercuri ▾.
- Title:** Download Area Sample
- Request Information:** Request: Nhundiaquara
- Supporting Files:** A table listing files related to the request:

File	Description	Size
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
- Download List:** A table showing the selected file for download:

Selected	Download ▾
<input type="checkbox"/> Name ↑	Size ↑
<input checked="" type="checkbox"/> MOD16A2GF.006_500m_aid0001.nc	4.84 MB
- Page Footer:** 1 - 1 displayed, 1 in total

# Download the data - File formats, projections

- QGIS or Colab - Shapefile preparation -> zipfile (Aula 2)
- 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  $\text{kg}/\text{m}^2/\text{8-day} = \text{mm}/\text{8-day}$
- 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

