

# TEA018 - Hidrologia Ambiental

Evapotranspiration data from Satellite MODIS product

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# Outline

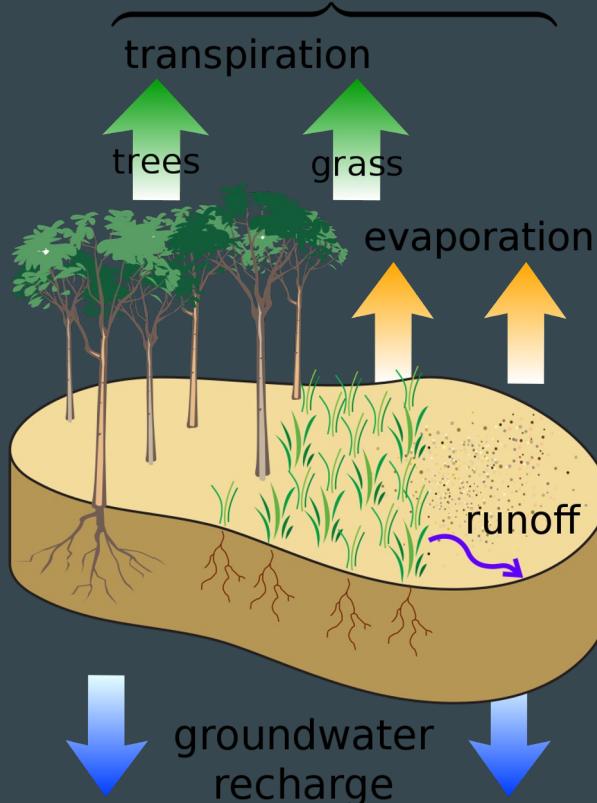
- Understand what is Evapotranspiration
- Water balance in river basins, Forest photosynthesis
- Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)
- Download the data
- Import the data into Google Colab
- Resample the data
- Plot and compare different watersheds

# What is Evapotranspiration?

# What is Evapotranspiration?

- Transpiration + Evaporation
- Potential x Real evapotranspiration

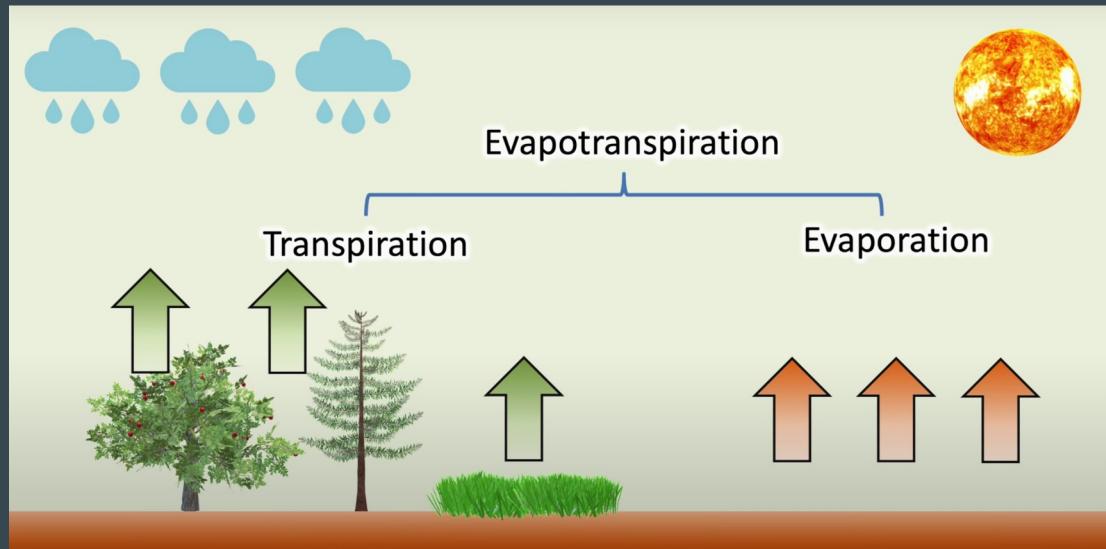
evapotranspiration =  
transpiration + evaporation



# 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**.

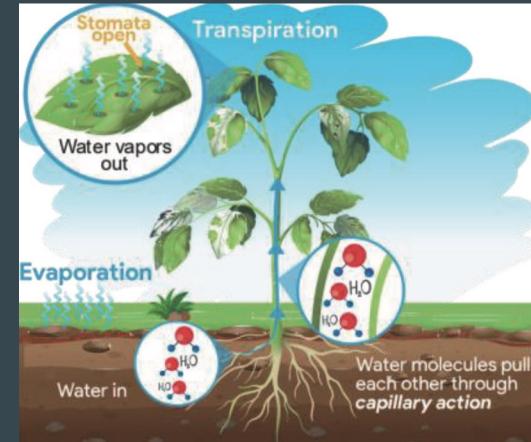
[https://en.wikipedia.org/wiki/Non-vascular\\_plant](https://en.wikipedia.org/wiki/Non-vascular_plant)

# Transpiration in Vascular Plants

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



it goes back to the atmosphere!

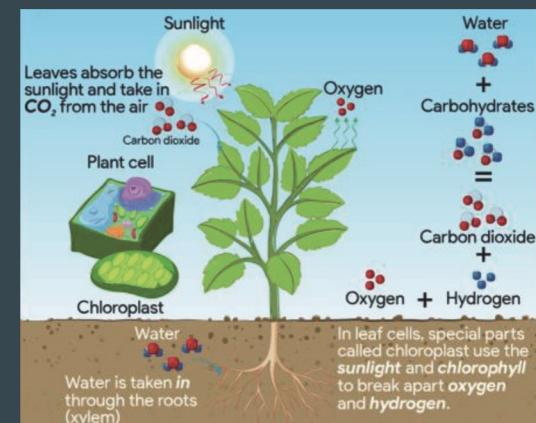


transpiration

## Photosynthesis

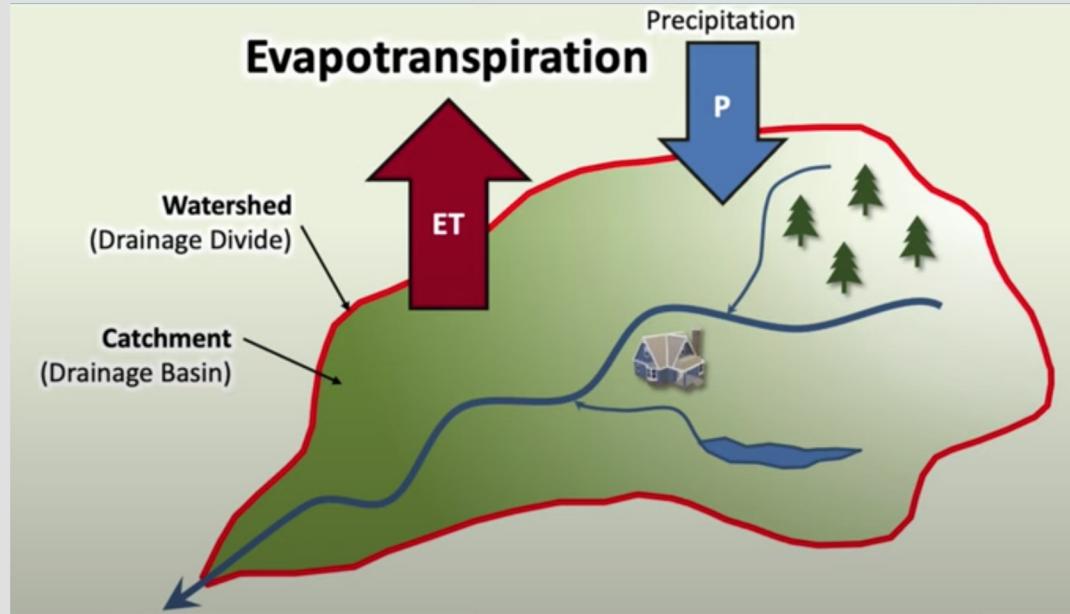


- To make sugars, plants must absorb carbon dioxide (CO<sub>2</sub>) from the atmosphere through **stomata**.



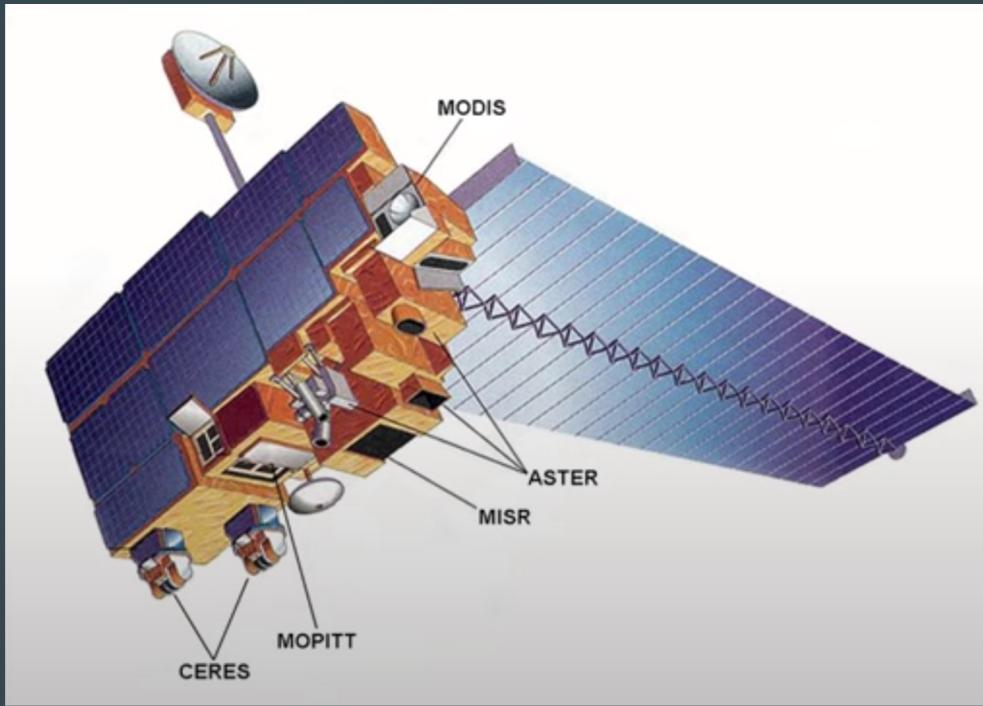
photosynthesis

# 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"

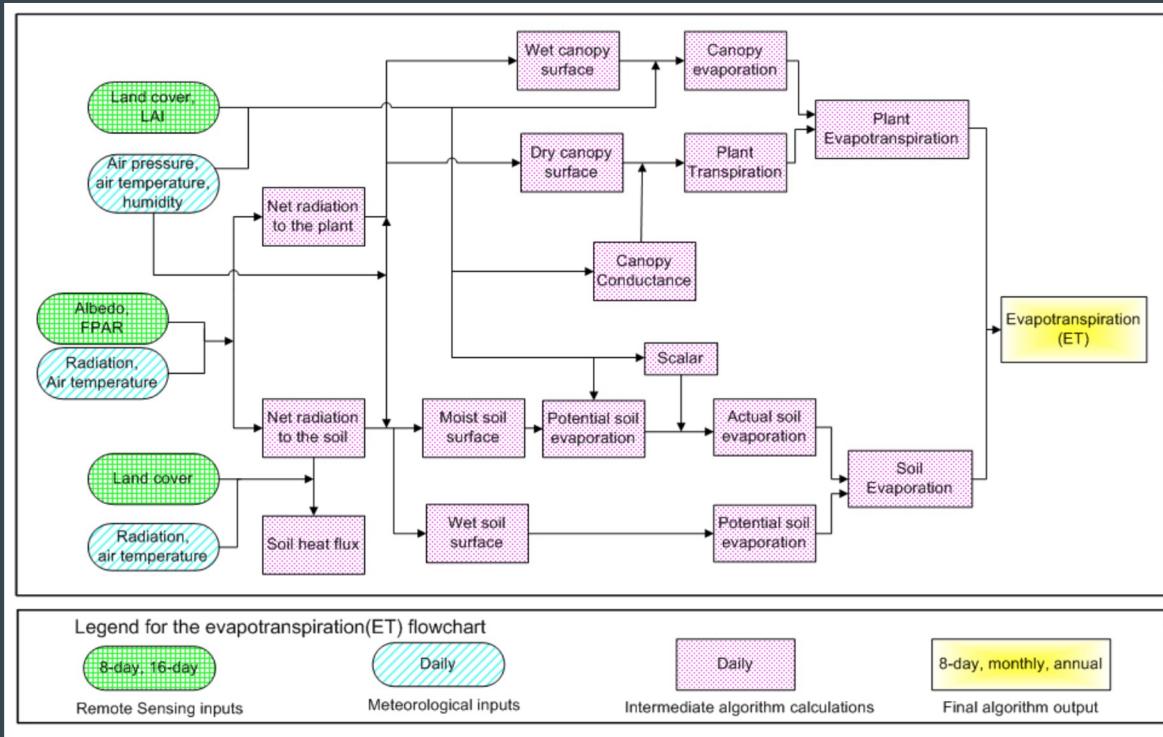
# MODIS MOD16 ET Product

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

# MODIS MOD16 ET Product

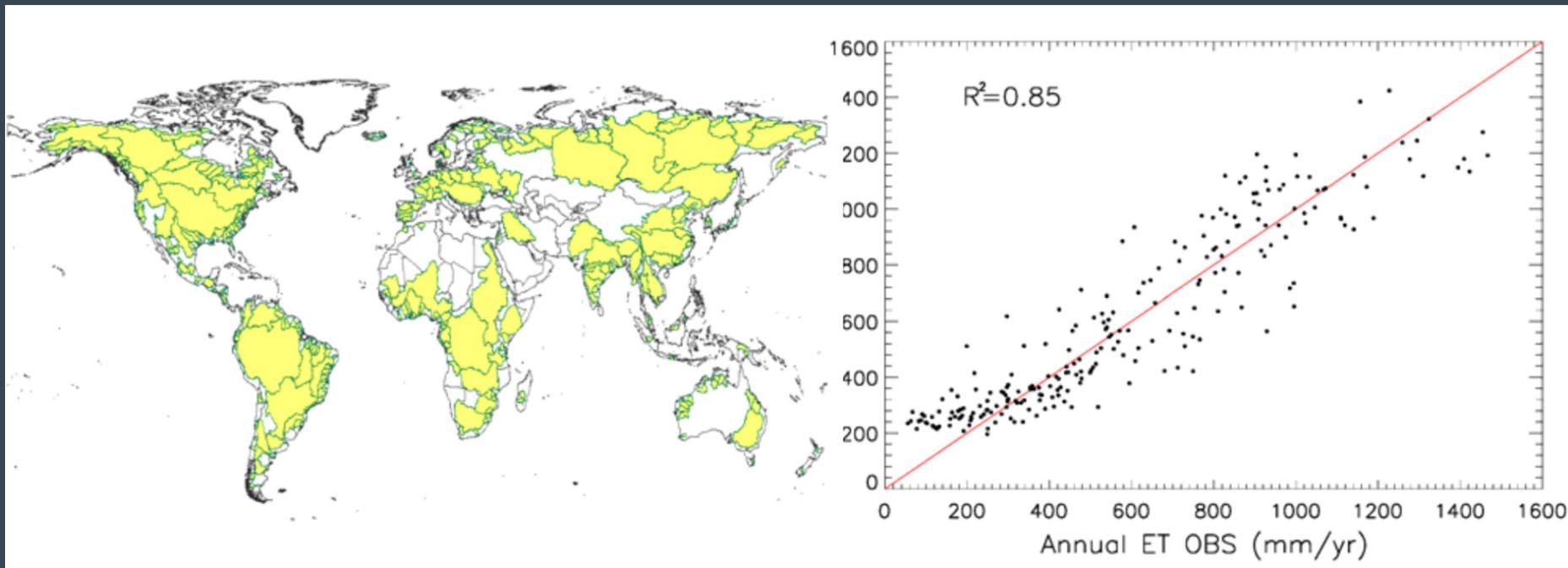
- MODIS ET algorithm follows the Penman-Monteith equation.
- Includes evaporation from wet and moist soil, evaporation from rainwater intercepted by the canopy before it reaches the ground, and the transpiration through stomata on plant leaves and stems
- The MOD16A2/A3 ET products are produced at the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

# Flowchart of the improved MOD16 ET algorithm.



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

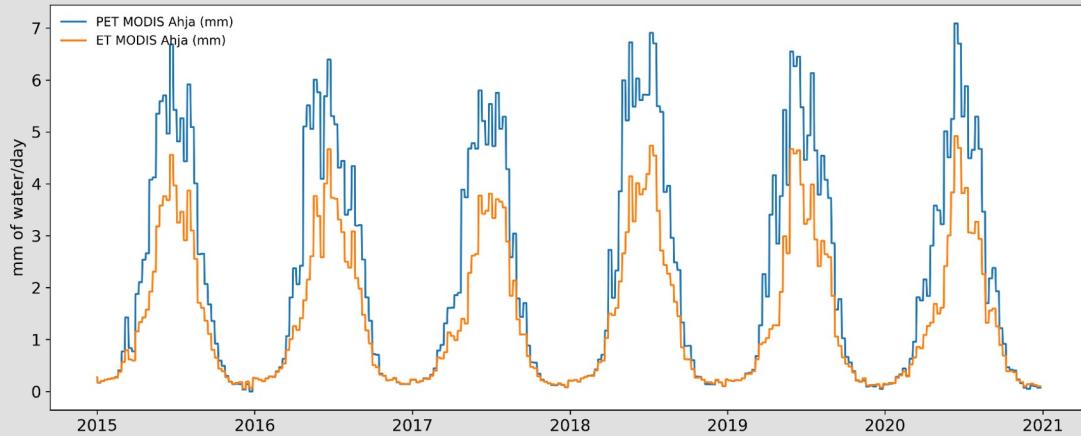
# Algorithm Performance at Global Watersheds



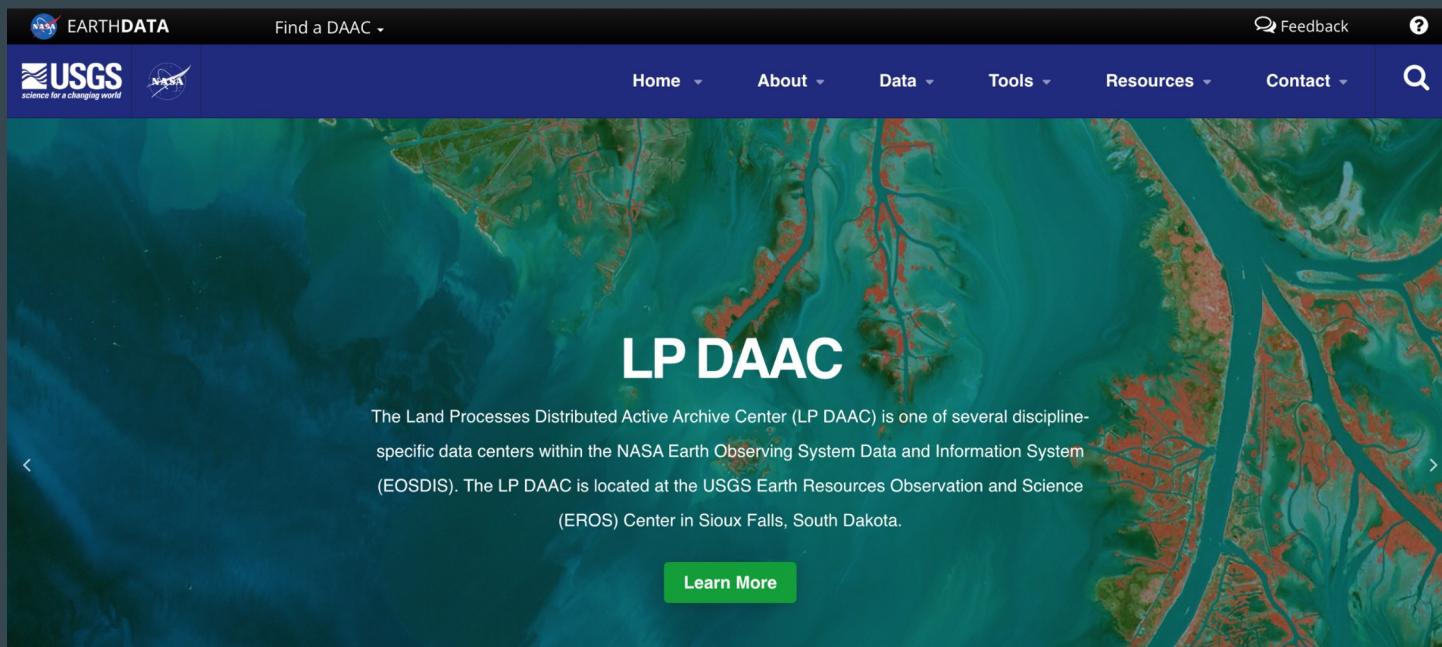
The MOD16 ET estimates can explain 85% of the variations of the pseudo-ET observations for 232 river basins.

# Time series: 2015 to 2021

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

# Search Data Catalog

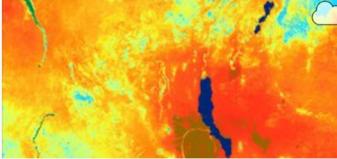
Search

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

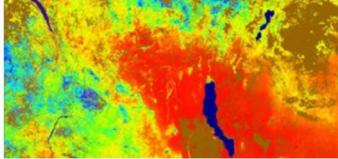
**KEYWORD: EVAPOTRANSPIRATION (ET)** **SPATIAL RESOLUTION (M): 500.0** **STATUS: OPERATIONAL** [Clear filters](#)

Showing 1 - 14 of 14 results

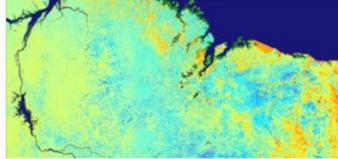
[Cards](#) [List](#)



**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 \(ET\)](#)



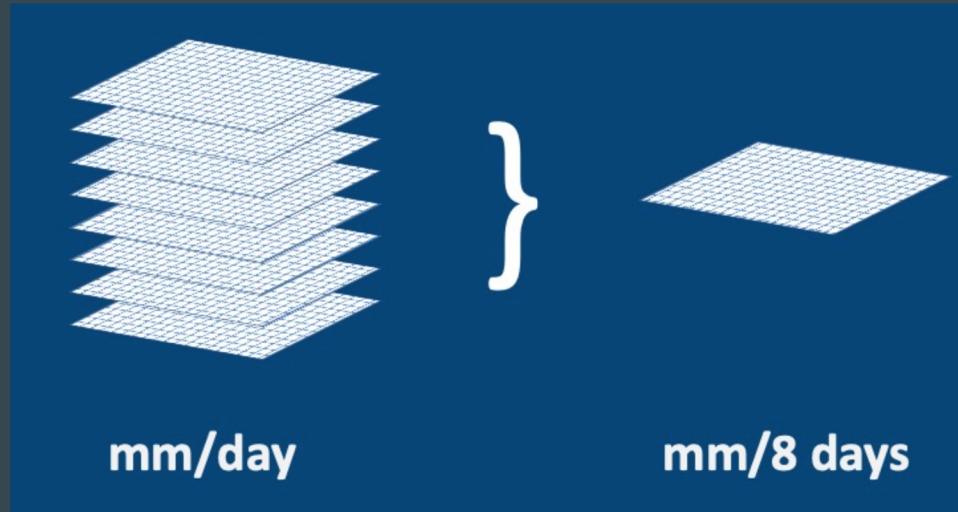
**MOD16A2GF v061**  
MODIS/Terra Net Evapotranspiration Gap-Filled 8-Day L4 Global 500 m SIN Grid  
[TERRA MODIS](#) [EVAPOTRANSPIRATION \(ET\)](#)

**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



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 sub-headline "Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)". Below this, a detailed description explains the application's purpose: "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." The bottom right corner of the main content area contains the "EARTHDATA" logo.

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!

# 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 shows the AppEEARS web application interface. At the top, there's a navigation bar with the logo, 'Extract', 'Explore', 'Help', and a user profile for 'emiliomercuri'. Below the navigation is a main form area.

**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)

**Selected file (bacia\_estacao84)**

A map view showing a green polygon representing the area of interest. The map includes labels like 'TIBA' and 'Pico Pará'. A coordinate tooltip at the bottom left shows 'Lat: -25.602 Lon: -48.645'. Below the map is a note: 'To clear a polygon, draw a new polygon or upload a vector polygon file.'

**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)  
MOD16A2GF006, 500m, 8 day, (2000-01-01 to Present)**

**Selected layers**

- ET\_500m
- PET\_500m
- ET\_QC\_500m

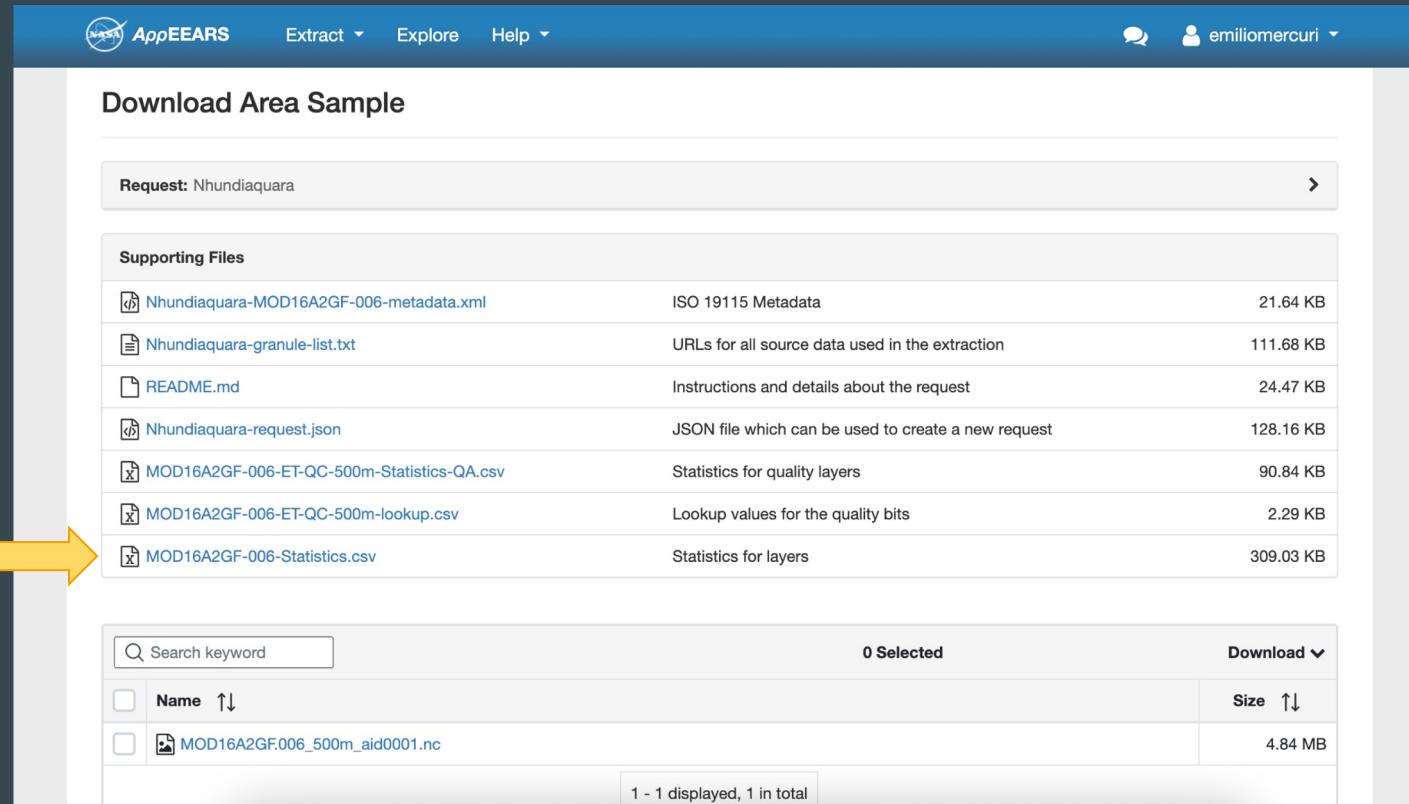
# AppEEARS - data from Estonia, Afghanistan and Brazil

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". On the right side of the header, there is a user profile icon and the name "emilioromerci". Below the header, a message box displays a warning: "Some MODIS/Terra Snow Cover v6.1 (MOD10A2) tiles are currently unavailable to AppEEARS. Requests containing MOD10A2 data may result in processing errors." A link "Please see Sample Request Retention for details on expired requests." is also present. The main content area is titled "Explore Requests" and shows a table of 17 requests. The table has columns for "Request", "Type", "Status", "Details", "Date Submitted", and "Date Completed". Each row contains a set of buttons for managing the request, including download, upload, delete, and a refresh/cancel button.

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

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
- Footer:** 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  $\text{kg/m}^2/\text{8-day} = \text{mm}/\text{8-day}$
- 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

