

# Big Data, organization and analysis

Evapotranspiration data from Satellite MODIS product

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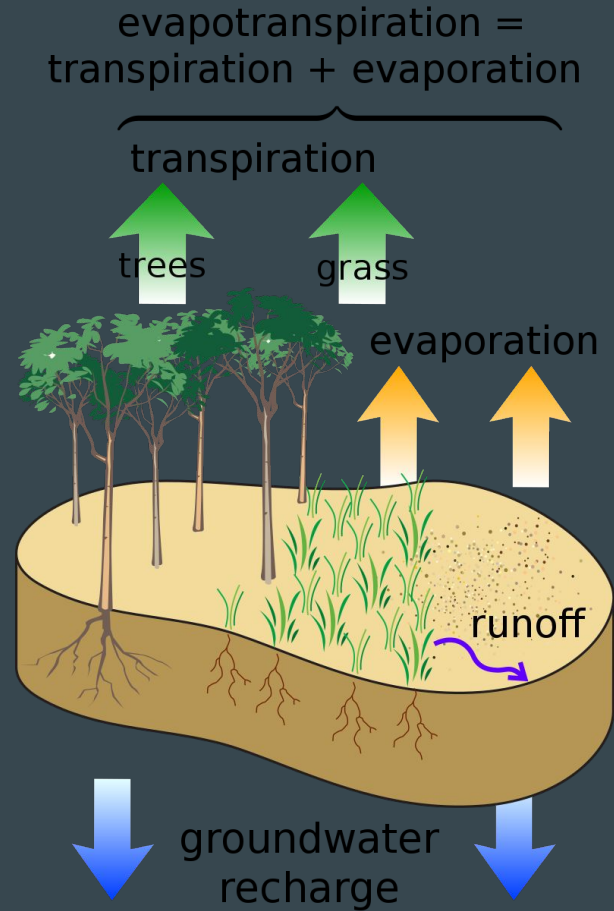
# Outline

- 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?

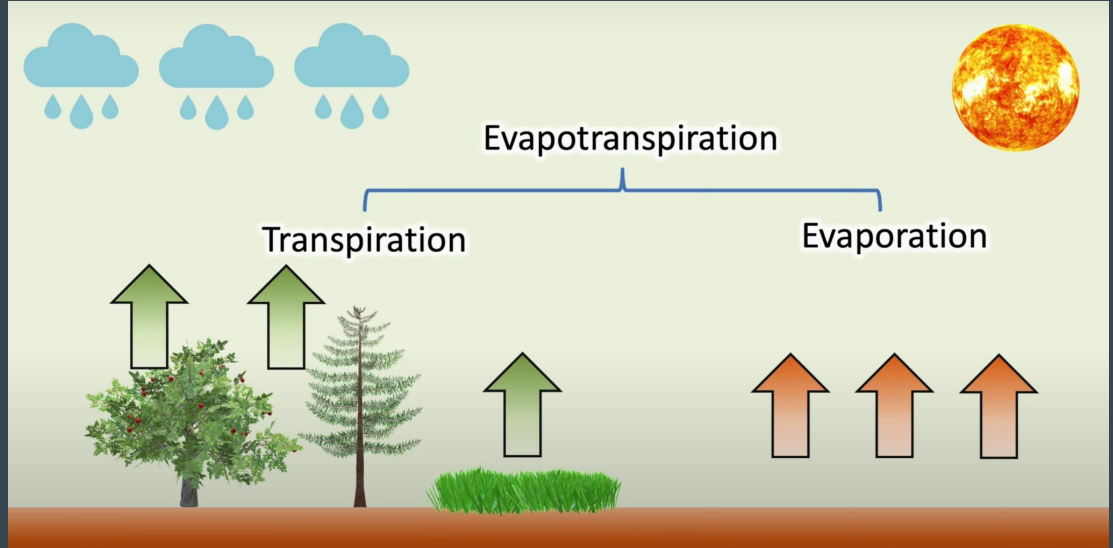
- Transpiration + Evaporation
- Potential x Real evapotranspiration



# 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](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](https://en.wikipedia.org/wiki/Non-vascular_plant)

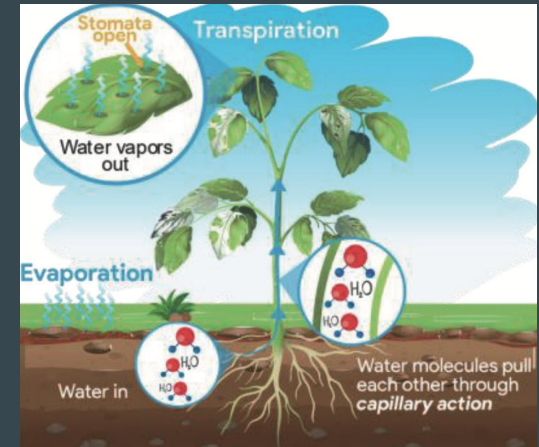
# Transpiration in Vascular Plants

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

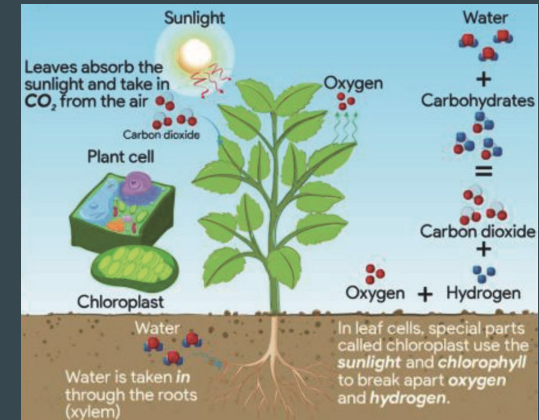
## Photosynthesis



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

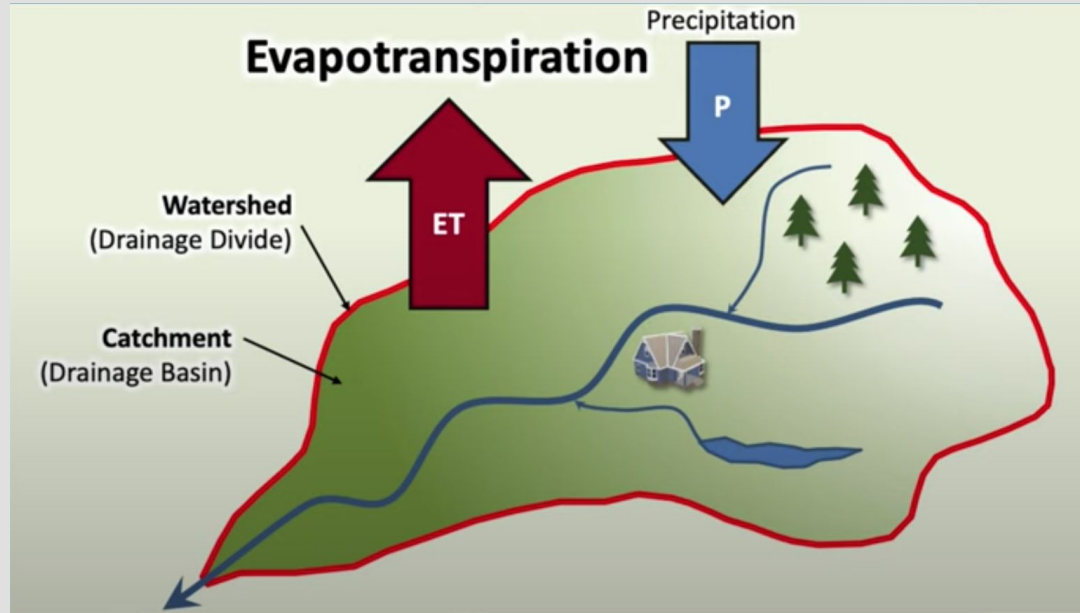


transpiration



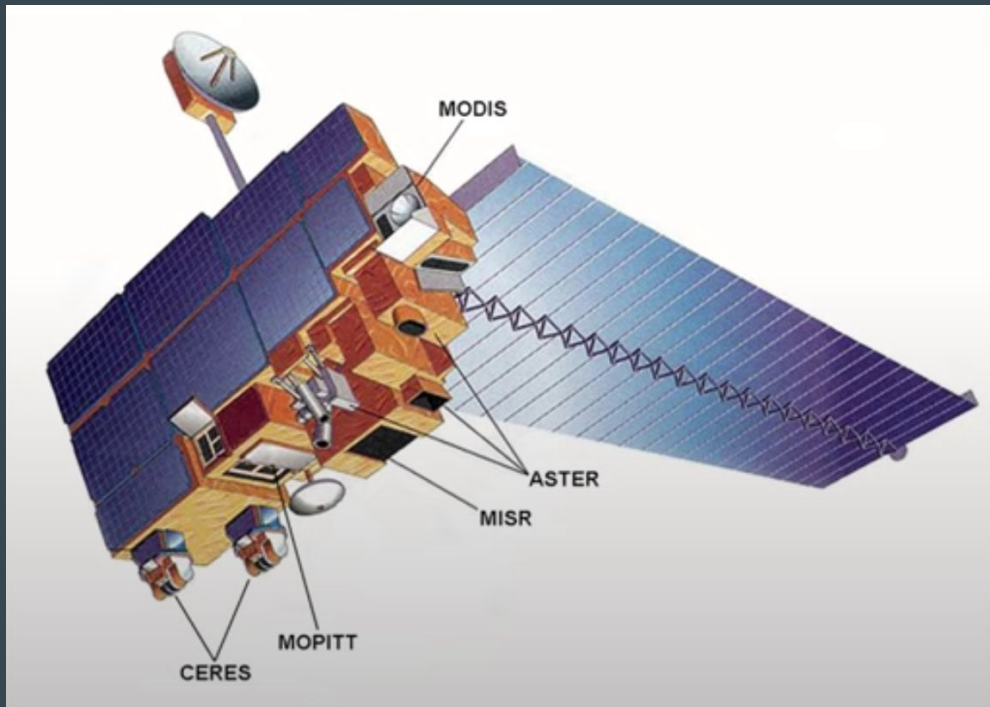
photosynthesis

# Water balance in river basins



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[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"



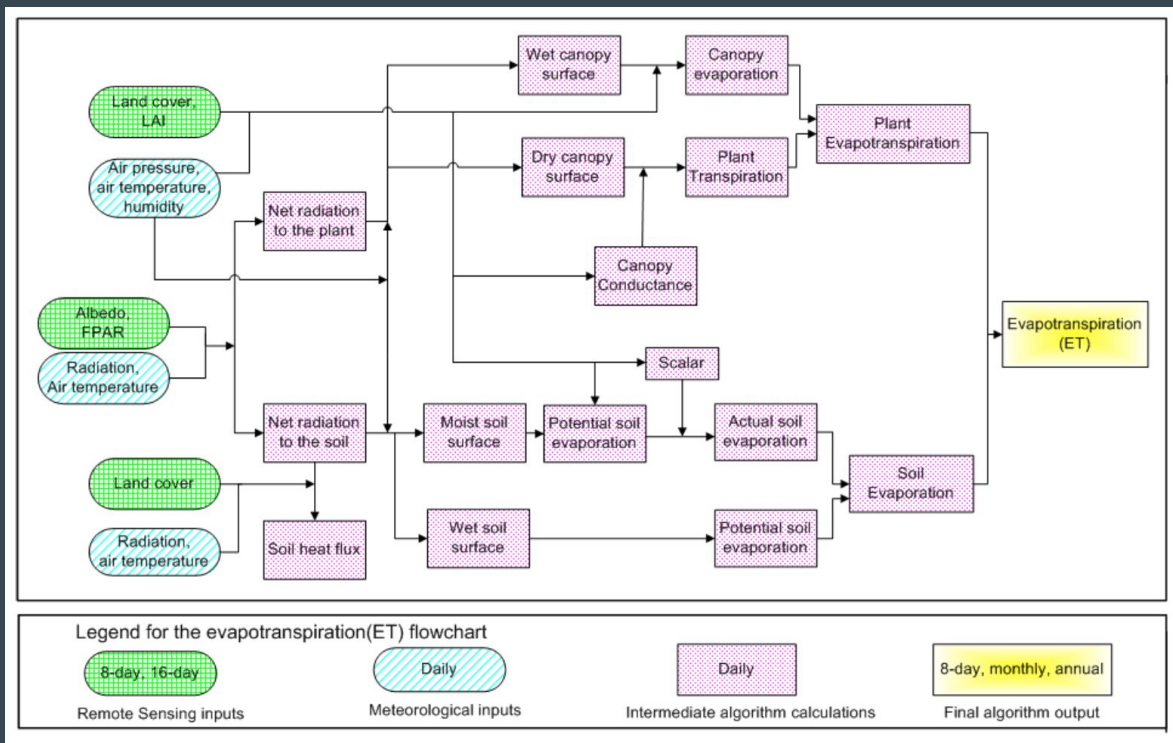
# MODIS MOD16 ET Product

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

# MODIS MOD16 ET Product

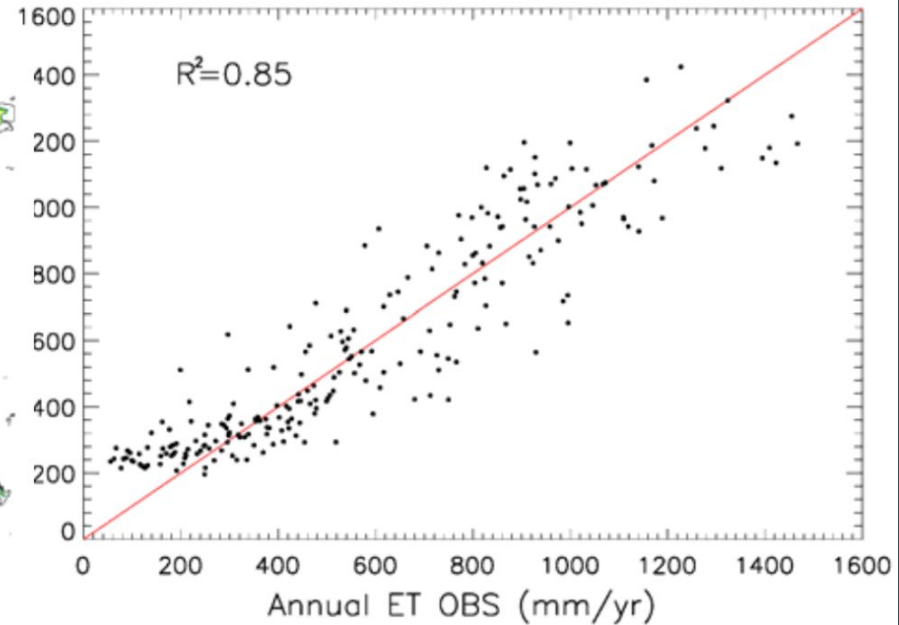
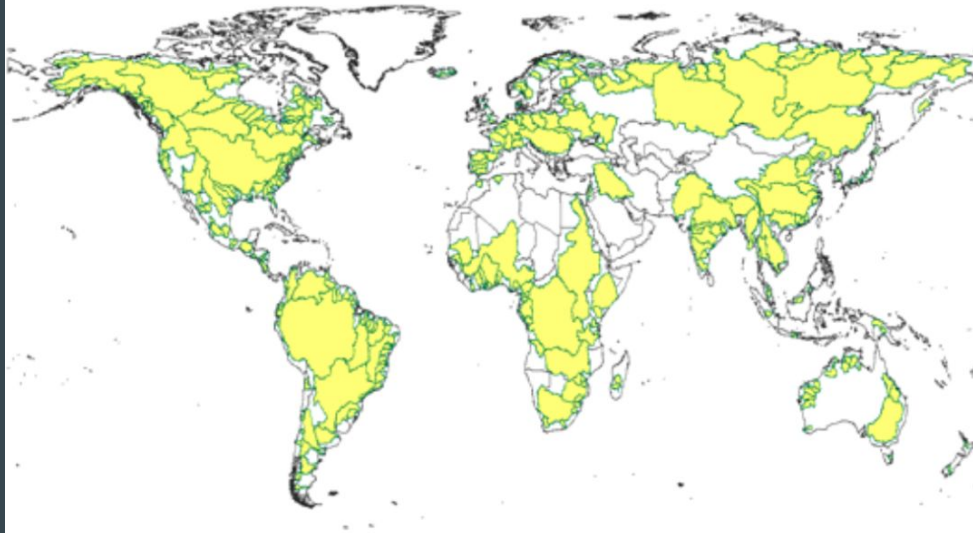
- MODIS ET algorithm follows the Penman-Monteith equation.
- Includes evaporation from wet and moist soil, evaporation from rainwater intercepted by the canopy before it reaches the ground, and the transpiration through stomata on plant leaves and stems
- The MOD16A2/A3 ET products are produced at the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

# Flowchart of the improved MOD16 ET algorithm.



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

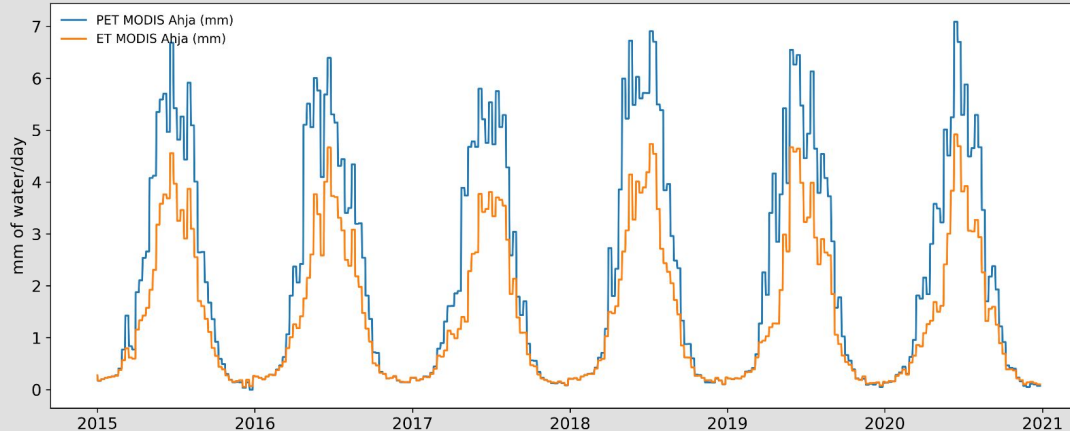
# Algorithm Performance at Global Watersheds



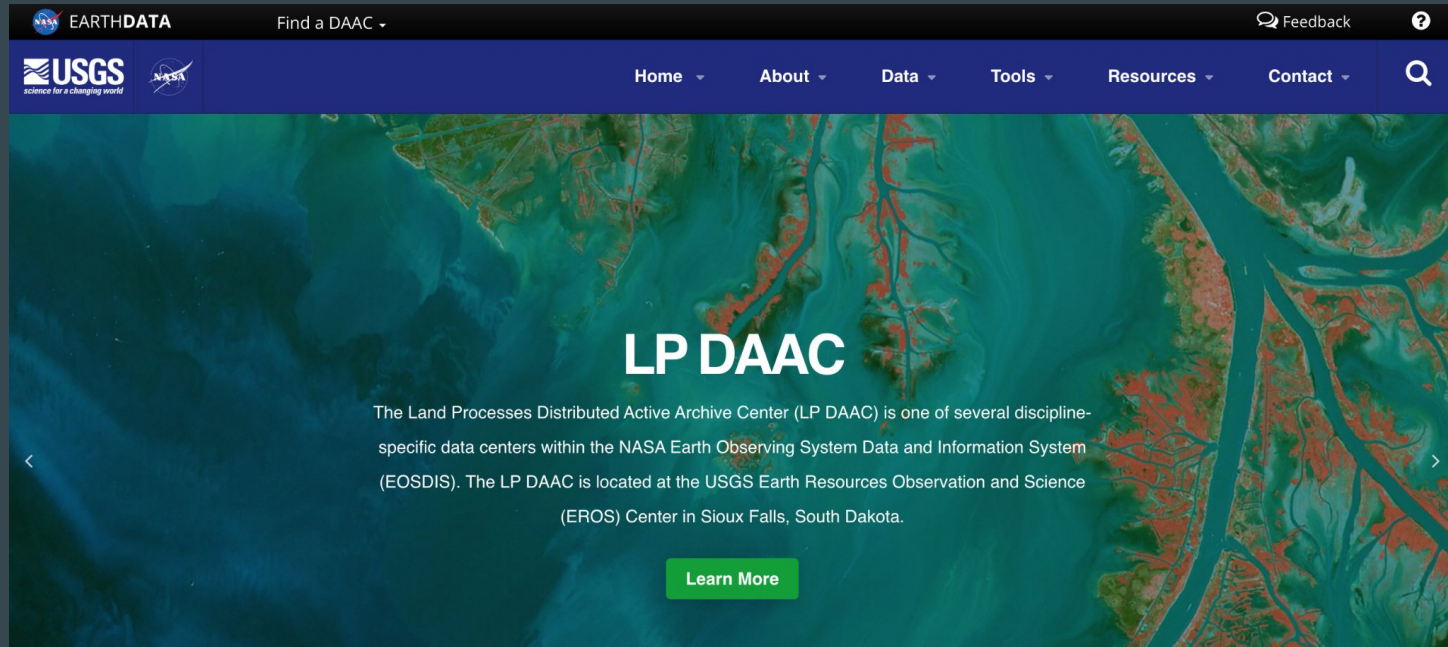
The MOD16 ET estimates can explain 85% of the variations of the pseudo-ET observations for 232 river basins.

# 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/>

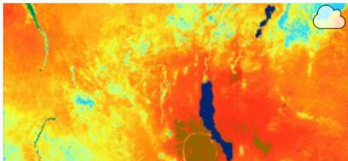
# Search Data Catalog

What are you looking for... Search

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

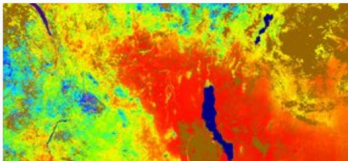
KEYWORD: EVAPOTRANSPIRATION (ET) × SPATIAL RESOLUTION (M): 500.0 × STATUS: OPERATIONAL × [Clear filters](#)

Showing 1 - 14 of 14 results Cards List



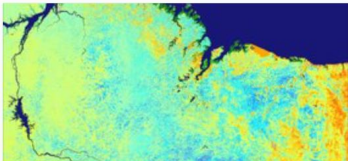
**MOD16A2 v061**  
MODIS/Terra Net Evapotranspiration 8-Day  
L4 Global 500 m SIN Grid

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

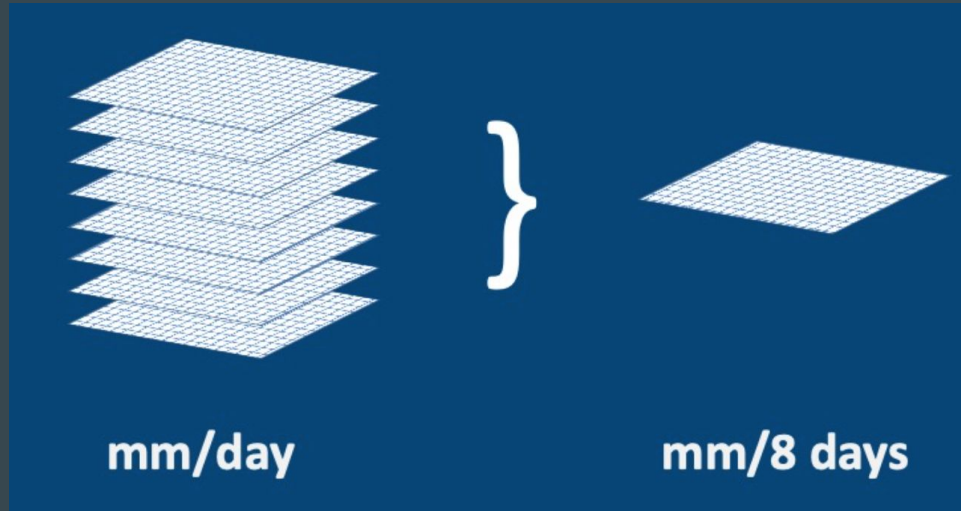
<https://lpdaac.usgs.gov/>

# 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



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!



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**

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)

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 a navigation bar with 'AppEARS', 'Extract', 'Explore', and 'Help' menus. A user profile 'emiliomercuri' is logged in. A blue banner at the top of the main content area 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 is active. It shows 'Showing requests 1 - 17 of 17' with pagination controls. A table lists the requests with columns: Request, Type, Status, Details, Date Submitted, and Date Completed. The table contains five entries, with the first two in progress and the last three expired. Each row has icons for viewing details, downloading, and deleting.

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	99%		03-10-2023 3:54:45 PM GMT-3	
Ahja watershed MOD16 ET & PET	Area Sample	45%		03-10-2023 3:50:05 PM GMT-3	
Temperatura_Kalli	Area Sample	Expired		01-19-2023 11:31:58 AM GMT-3	01-19-2023 12:48:25 PM GMT-3 
Reola watershed MOD16 ET & PET	Area Sample	Expired		01-11-2023 11:32:41 AM GMT-3	01-11-2023 5:13:17 PM GMT-3 
Kalli watershed MOD16 ET & PET	Area Sample	Expired		01-11-2023 9:36:47 AM GMT-3	01-11-2023 10:20:39 AM GMT-3 

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**

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

0 Selected Download ▾

<input type="checkbox"/>	Name ↑↓	Size ↑↓
<input type="checkbox"/>	 <a href="#">MOD16A2GF006_500m_aid0001.nc</a>	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

