

# Big Data, organization and analysis

Evapotranspiration data from Satellite MODIS product

Emílio Graciliano Ferreira Mercuri, March of 2023  
Estonian University of Life Sciences (EMÜ)

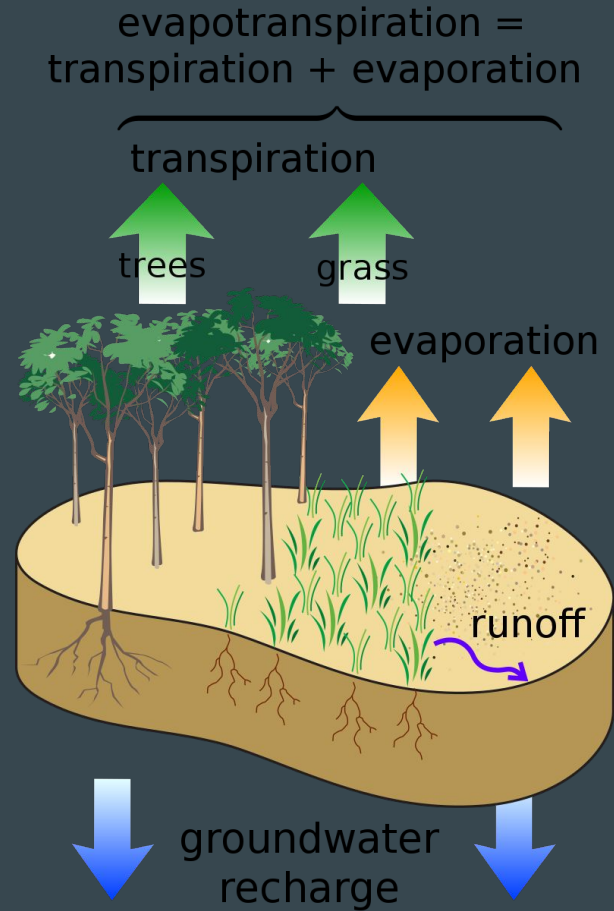
# Outline

- 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?

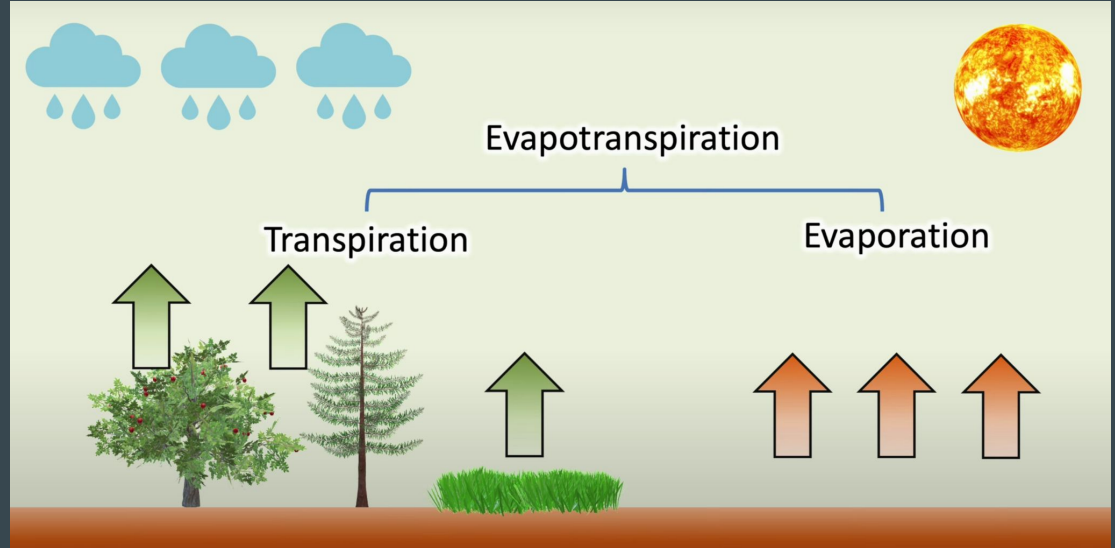
- Transpiration + Evaporation
- Potential x Real evapotranspiration



# 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\\_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)

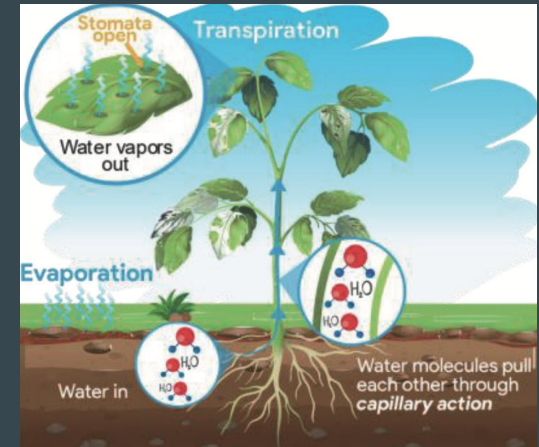
# Transpiration in Vascular Plants

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

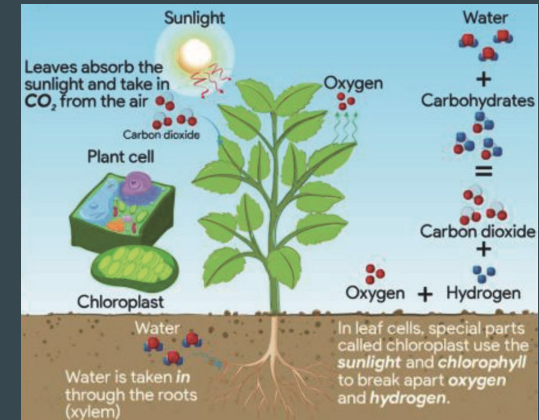
## Photosynthesis



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

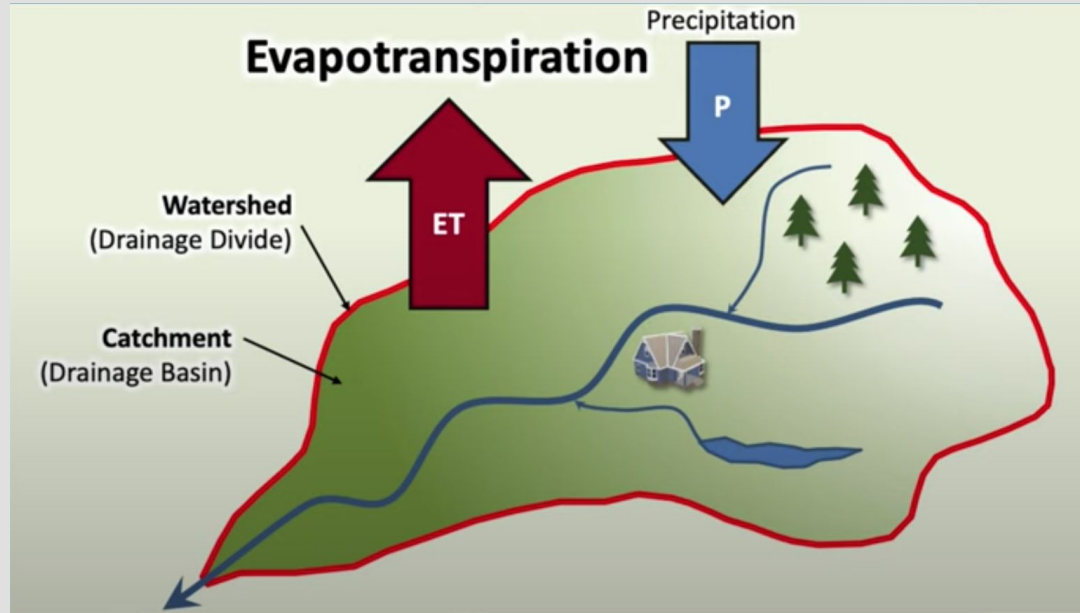


transpiration



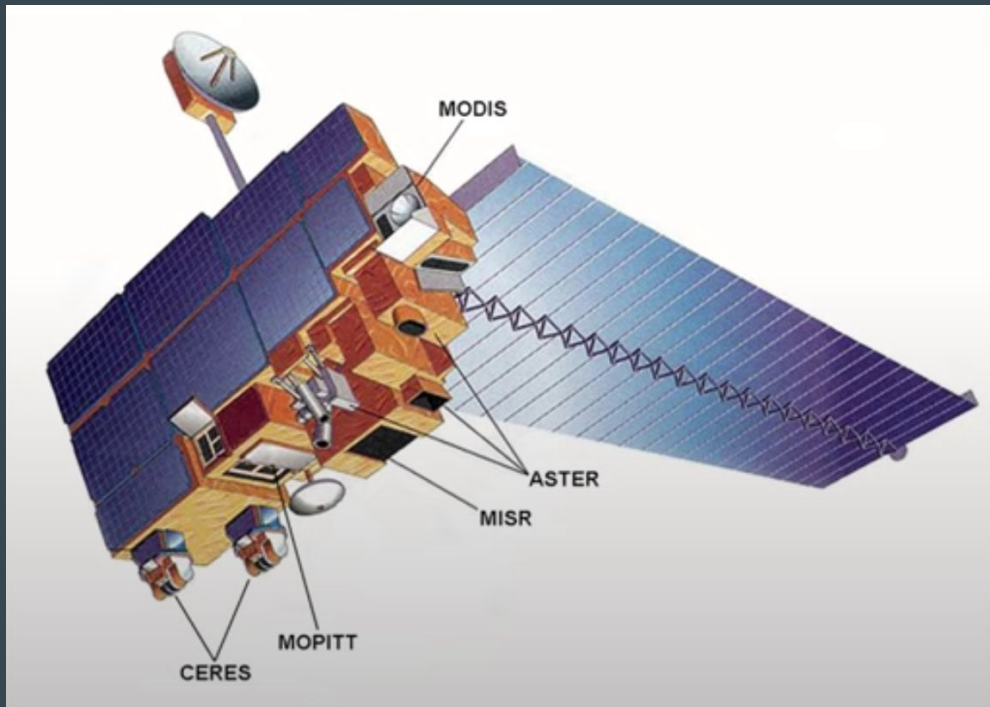
photosynthesis

# Water balance in river basins



Introduction to MODIS Evapotranspiration (MOD16) - a free global dataset of ET & PET  
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# What is MODIS?



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



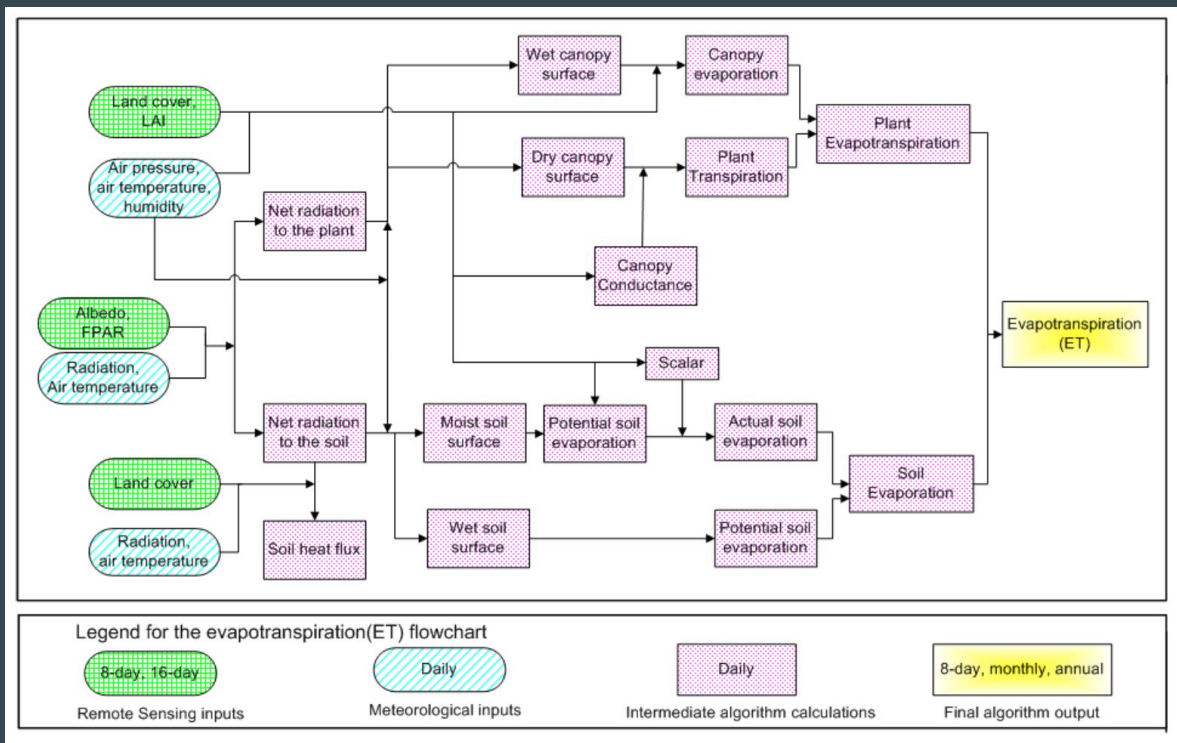
# MODIS MOD16 ET Product

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

# MODIS MOD16 ET Product

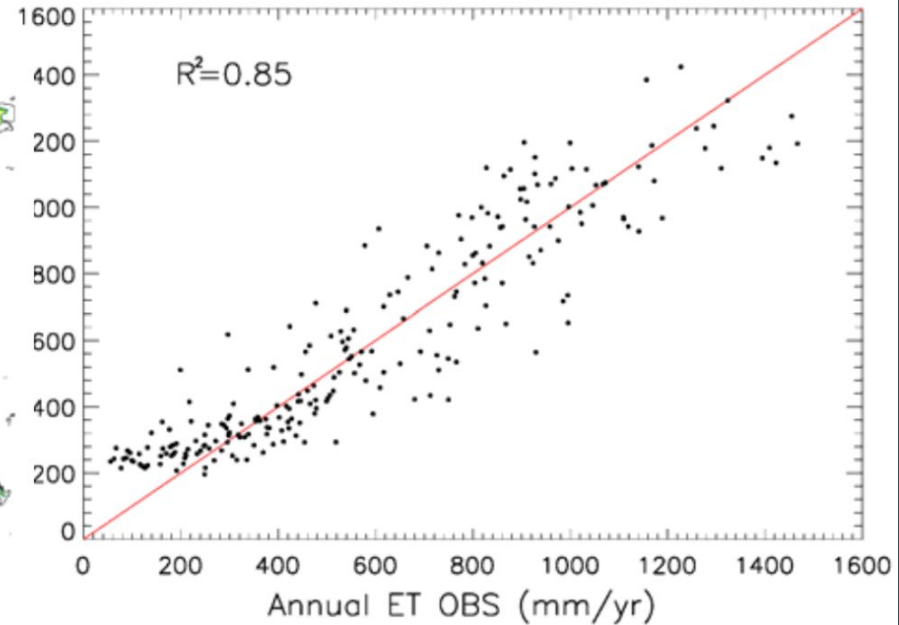
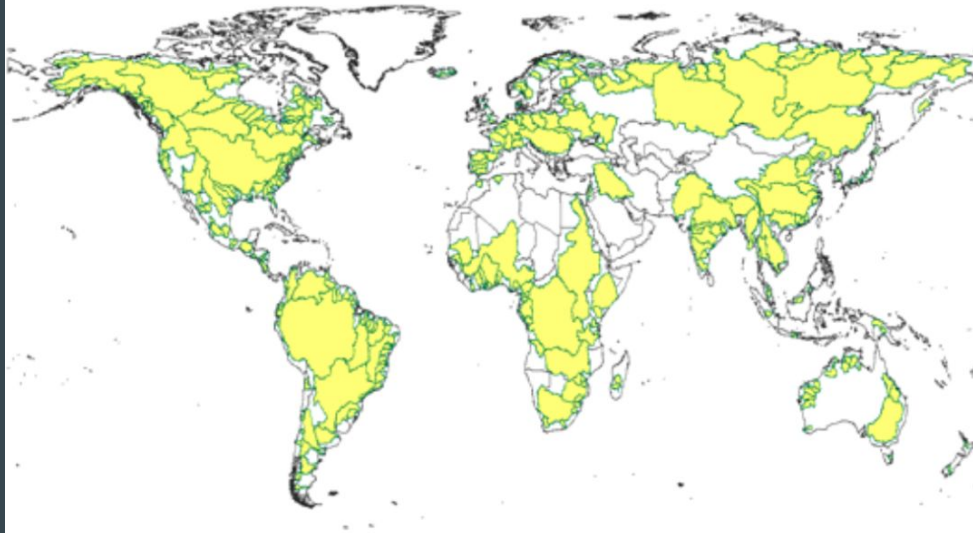
- ❖ MODIS ET algorithm follows the Penman-Monteith equation.
- ❖ Includes evaporation from wet and moist soil, evaporation from rainwater intercepted by the canopy before it reaches the ground, and the transpiration through stomata on plant leaves and stems
- ❖ The MOD16A2/A3 ET products are produced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

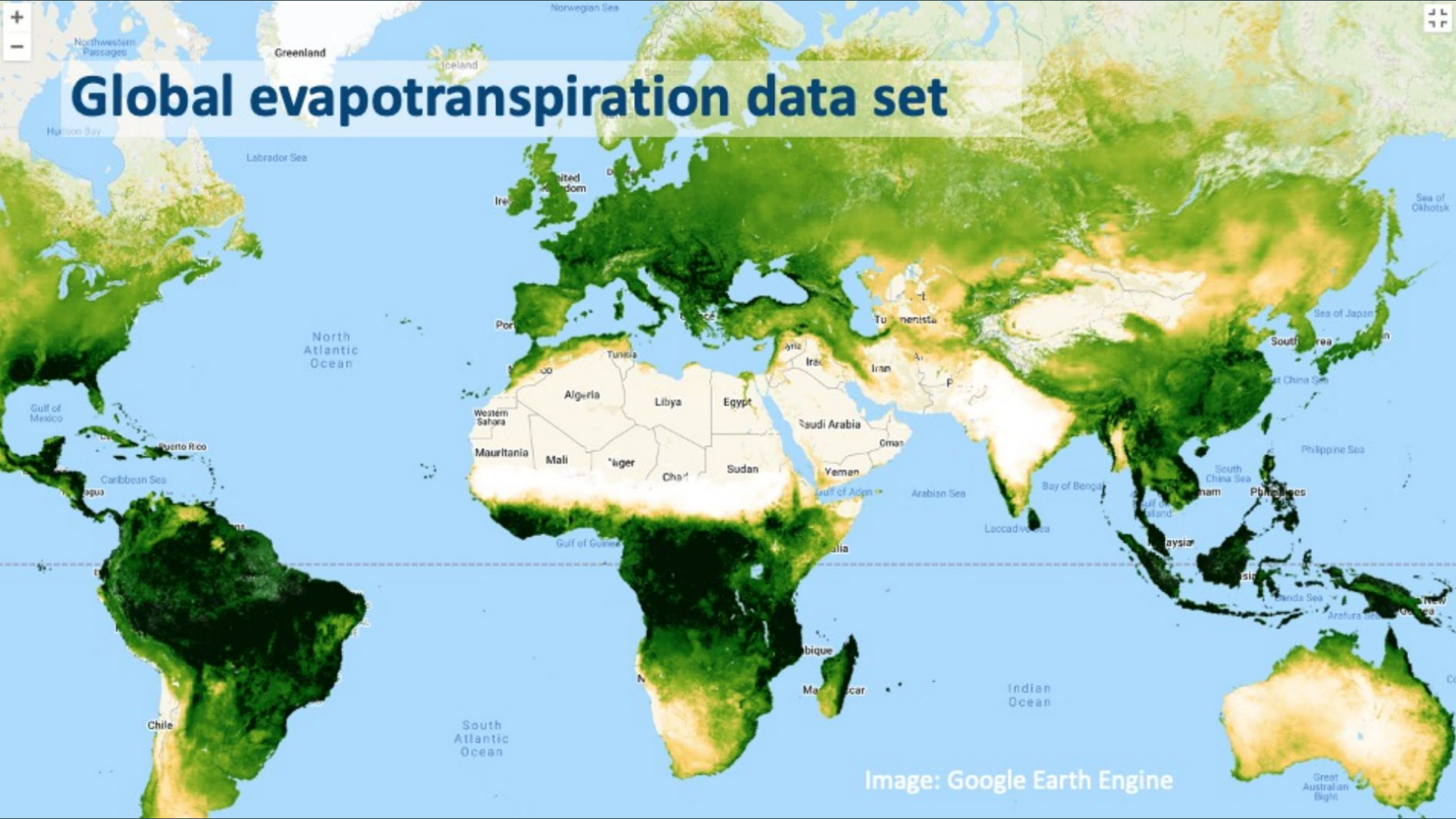


Image: Google Earth Engine



**Spatial resolution: 500 x 500 m**

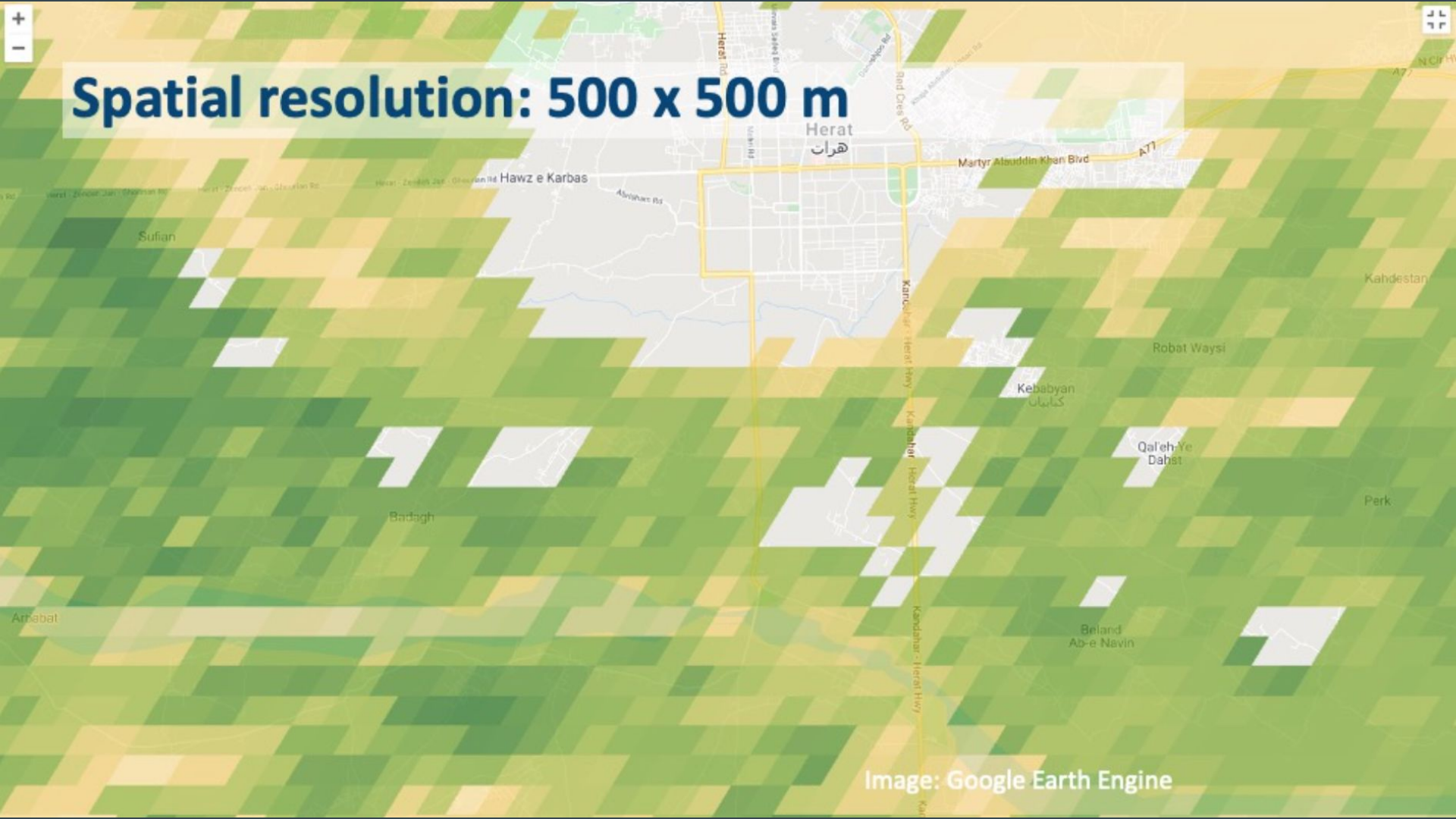
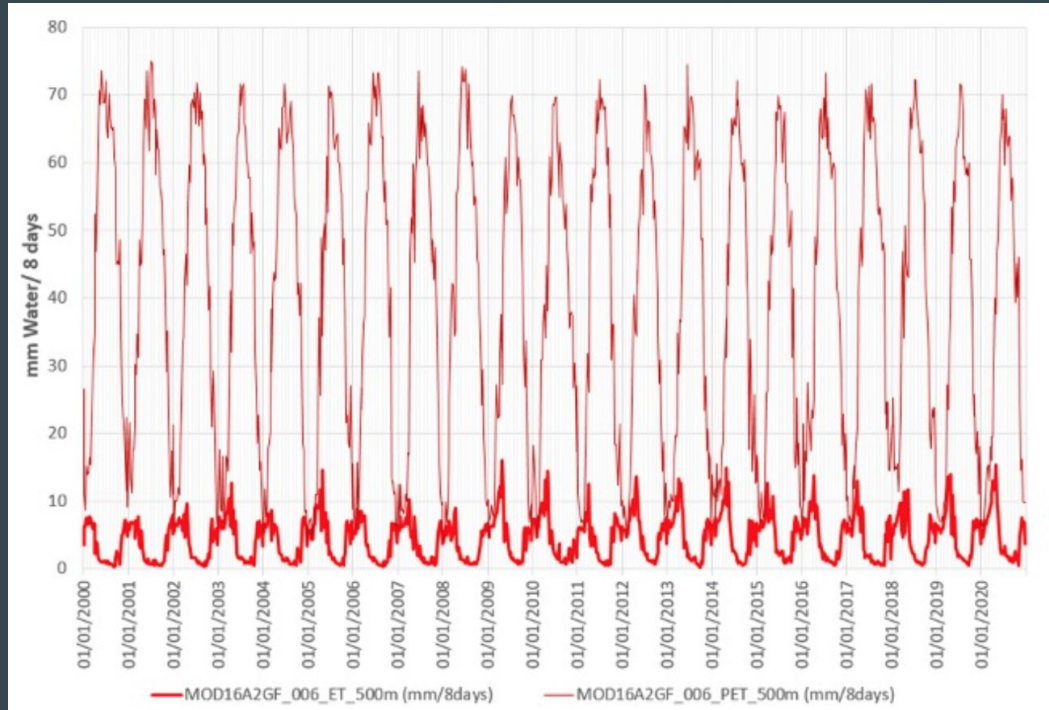
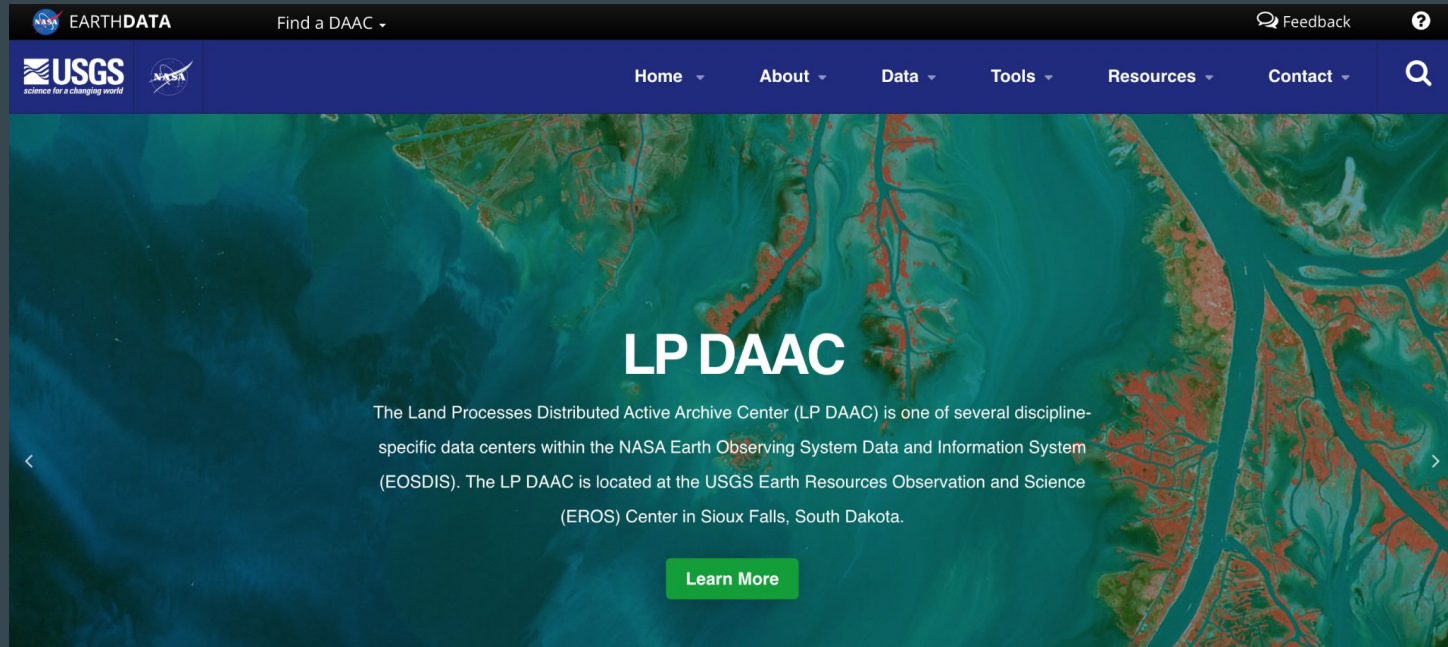


Image: Google Earth Engine

# 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/>



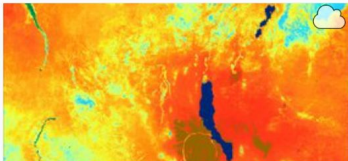
# Search Data Catalog

What are you looking for... Search

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

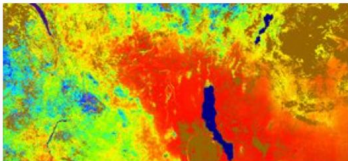
KEYWORD: EVAPOTRANSPIRATION (ET) × SPATIAL RESOLUTION (M): 500.0 × STATUS: OPERATIONAL × [Clear filters](#)

Showing 1 - 14 of 14 results Cards List



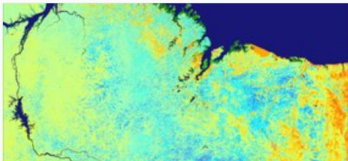
**MOD16A2 v061**  
MODIS/Terra Net Evapotranspiration 8-Day  
L4 Global 500 m SIN Grid

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)

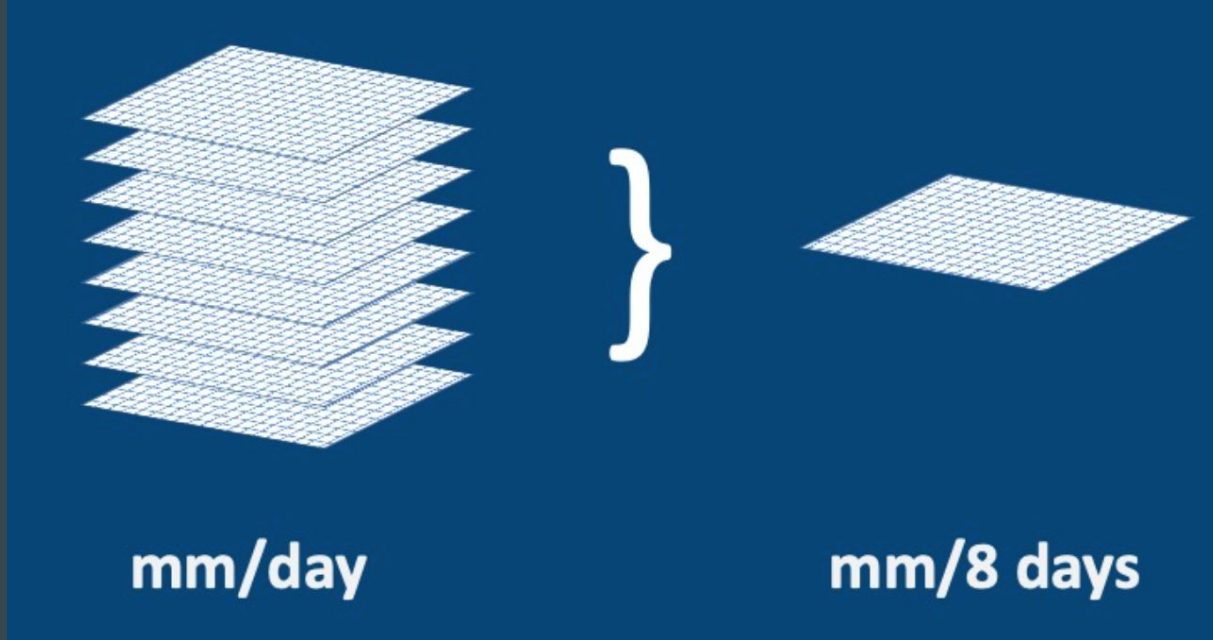
MOD16A2.\* and MOD16A2GF.\* files

<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 2 Shapefiles (perimeter of the water basins)
  - Nhundiaquara river (Paraná - Brazil)
  - Ahja river (Estonia)
- ❖ Download the 2 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 several sections:

- Upload a file or draw a polygon using the [icon] or [icon] icon**: This section includes instructions to 'Drop a vector polygon file containing the area feature(s) to extract or click here to select the file.' and lists supported file formats: Shapefile (.zip including .shp, .dbf, .prj, and .shx files) and GeoJSON (.json or .geojson).
- Start Date** and **End Date**: Two date pickers are shown, with 'Start Date' set to '01-01-2000' and 'End Date' set to '01-01-2023'. Below these is a checkbox for 'Is Date Recurring?' which is currently unchecked.
- Select the layers to include in the sample**: A list of layers is shown, with 'Terra MODIS Net Evapotranspiration Gap-Filled (ET & LE) MOD16A2GF.006, 500m, 8 day, (2000-01-01 to Present)' selected and highlighted in blue. Below it, 'ET\_QC\_500m' is also visible.
- Selected file (bacia\_estacao84)**: A map view shows a satellite image of a region with a green polygon overlay. The map includes a scale bar, a north arrow, and coordinates 'Lat: -25.602 Lon: -48.645'. Below the map, it says 'To clear a polygon, draw a new polygon or upload a vector polygon file.'
- Selected layers**: A list of selected layers is shown, including 'ET\_500m' and 'PET\_500m', both with a resolution of '500m, 8 day'.

# AppEARS - data from Estonia and Brazil

The screenshot displays the AppEARS web interface. At the top, there's a header with the NASA EarthData logo, the text "Other DAACs -", and the AppEARS logo. Navigation links for "Extract", "Explore", and "Help" are present, along with a user profile "emiliomercuri". 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 is visible, with a sub-header "Please see Sample Request Retention for details on expired requests." It shows "Showing requests 1 - 17 of 17" and a pagination control with "« Prev", "1", and "Next »". A table lists the requests with columns: Request, Type, Status, Details, Date Submitted, and Date Completed. The table contains five rows of data, including requests for "Nhundiaquara", "Ahja watershed MOD16 ET & PET", "Temperatura\_Kalli", "Reola watershed MOD16 ET & PET", and "Kalli watershed MOD16 ET & PET". Each row has a progress bar for the status and icons for details, download, and delete.

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/>

# Thanks! Let's code!

## Google Colab

What we will do:

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

