



GEO TUTORIAL

AUTOMATICALLY DOWNLOADING MULTIPLE
RASTER FILES FOR SINGLE OUTPUT

Krzysztof Raczynski
Kate Grala
John Cartwright

Geosystems Research Institute
Mississippi State University

SEPTEMBER 2024

This work was supported through funding by the National Oceanic and Atmospheric Administration Regional Geospatial Modeling Grant, Award # NA19NOS4730207.



GEOSYSTEMS RESEARCH INSTITUTE, MISSISSIPPI STATE UNIVERSITY, BOX 9627, MISSISSIPPI STATE, MS 39762-9652

The Geospatial Education and Outreach Project (GEO Project) is a collaborative effort among the Geosystems Research Institute (GRI), the Northern Gulf Institute (a NOAA Cooperative Institute), and the Mississippi State University Extension Service. The purpose of the project is to serve as the primary source for geospatial education and technical information for Mississippi.

The GEO Project provides training and technical assistance in the use, application, and implementation of geographic information systems (GIS), remote sensing, and global positioning systems for the geospatial community of Mississippi. The purpose of the GEO Tutorial series is to support educational project activities and enhance geospatial workshops offered by the GEO Project. Each tutorial provides practical solutions and instructions to solve a particular GIS challenge.

AUTOMATICALLY DOWNLOADING MULTIPLE RASTER FILES FOR SINGLE OUTPUT

Krzysztof Raczyński (chriss@gri.msstate.edu)
Kate Grala (kgrala@gri.msstate.edu)
John Cartwright (johnc@gri.msstate.edu)

Geosystems Research Institute,
Mississippi State University

REQUIRED RESOURCES



- Web browser of your preference with an active internet connection
- GIS software: QGIS 3+ or ArcGIS Pro 2.6+ (both are covered in this tutorial)
- Cygwin terminal for Windows users (installation will be covered in this tutorial)

OVERVIEW


This tutorial aims to teach you how to automate the download process for internet-shared raster datasets, such as elevation models or satellite imagery. We will also merge multiple files into a single output. You will learn how to use the NASA Earthdata repository to search for specific ranges of data and download it by automating the multiple file download processes. Finally, you will merge them into one file, limiting the number of files needed for further work. Knowledge of fundamental GIS concepts is expected, but you don't need any programming background to complete this tutorial.

To spark your interest, imagine yourself in the following situation: The Texas State authorities require a large-scale Digital Elevation Model (DEM) covering the state area to run flood-risk assessments. They contacted you to prepare the required data file. This tutorial will guide you through the necessary steps to successfully accomplish the task.

STEP 1. AUTOMATICALLY DOWNLOAD THE RASTER DATA

In this step, we will download the required data as raster tiles. We will use the Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) Version 3 (ASTGTM) dataset. The mission website and dataset description are available under the following link: <https://lpdaac.usgs.gov/products/astgtmv003/>

- Visit the website link provided above to learn about the dataset. After examining data specifications, click on the **ACCESS DATA** icon available above the dataset description. A pop-up will be displayed with

multiple engines available. We will be interested in the **NASA Earthdata Search** option due to its ability to automate the downloading process. Click on the download icon  in the **Download Data** column in the NASA Earthdata Search row. A new tab will open, presenting the Earthdata portal.

- B. In the newly opened window, first, you need to login to your account or create a new one for free. In the upper-right corner, click on **EARTHDATA LOGIN**. If you already have an account, **LOG IN**, otherwise, click **REGISTER** to create a new one. Once you are logged in, return to the data download website. If you are not redirected automatically, follow the provided link:

<https://search.earthdata.nasa.gov/search?q=C1711961296-LPCLOUD>

- C. Click the **RANGE SELECTION** tool available at the top of the left panel, and from the drop-down menu that was displayed, select **RECTANGLE** (Fig. 1).

- D. Draw a rectangle around State of Texas by clicking on the map and holding and dragging the mouse pointer until Texas is fully covered by your selection. The coordinates of your selection will be filled into the range box under **Spatial Rectangle** information. You can also, instead of drawing it manually, input the coordinates directly into the box and select them by pressing [ENTER]. In our case, the approximate selection should be:

SW: 25, -107
NE: 37, -93

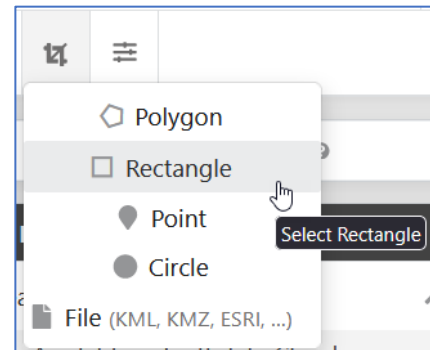


Fig. 1. Select Rectangle tool allows to limit the range of data searched and displayed to only region of interest.

- E. After selecting, the dataset under **ASTER Global Digital Elevation Model V003** will refresh to show all tiles falling under your selection (Fig. 2). If this didn't happen, try clicking the one ASTER data tile shown in the search result until you see a list of tiles (depending on your selection, you should see around 202 files).

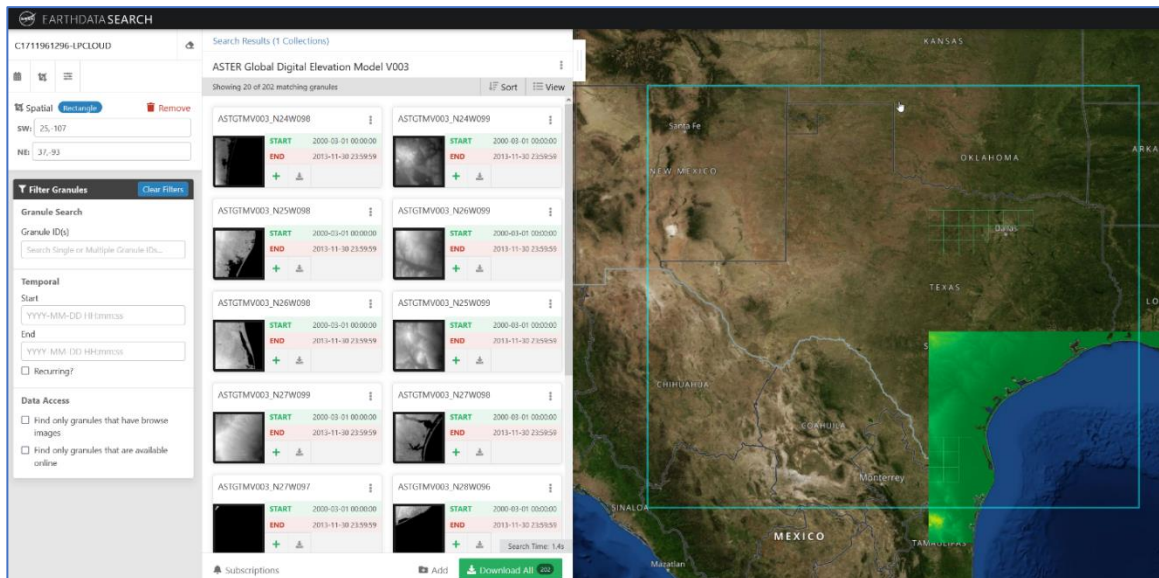


Fig. 2. A selection box applied over an area allows to limit the resulting files searched for within the data repository. These are displayed in the Search Result window on the left of the map.

- F. Downloading over 200 files manually would be a tedious task. That is why we will use the automated option. Click on **DOWNLOAD ALL** button.
- G. In the next step, the total number of files and their size (around 2.5 GB) will be displayed. Click the **DOWNLOAD DATA** button again.
- H. Once the system is done processing your new request, four options for downloading data will be displayed. Click on **Download Script** (Fig. 3) and then **Save**.

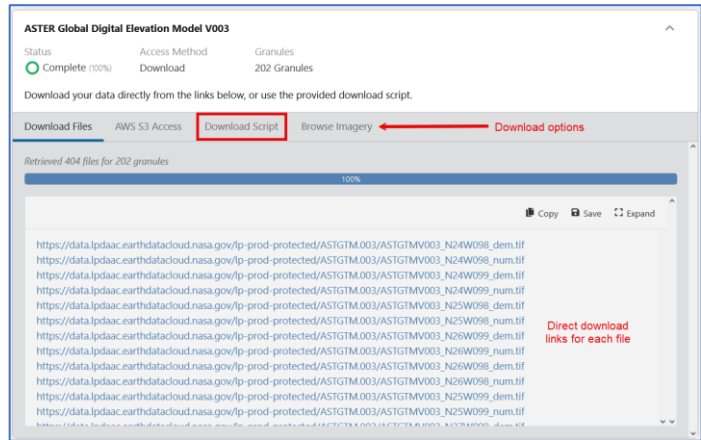


Fig. 3. There are multiple download options available, but thanks to *Download Script* option, the process can be automated.

- I. Choose the location where you want to save the data (remember to have enough disk space available for all the files). Rename the file to **download.sh**.
- J. We will need a terminal that is capable of accepting Unix commands. For Linux users, that will be a terminal provided in the system; however, for Windows users, a special program is needed. We will use **Cygwin**, a free tool that combines a large collection of GNU and open-source tools. For installation on Windows, follow these steps:
 - a. Visit the Cygwin website at <https://www.cygwin.com/>.
 - b. Click the setup link available under **Installing Cygwin** (usually *setup-x86_64.exe*).
 - c. Save the file on the drive and run it.
 - d. Follow the steps displayed in the installer. If asked about the source of the download (internet install), choose the link that seems to be the closest to your location (e.g., if you live in Germany, choose the links with the *.de* domain).
 - e. After installation is complete, run the program **Cygwin64 Terminal**.
- K. In the terminal window, you must navigate to the location of the file we have downloaded in step 1.i. You can do this by calling the command **cd** (as Change Directory), followed by the path to the file. For example, if your file is located at: *C:\DEM\files* then your command will be:

```
cd C:/DEM/files
```

You can check if you are in the correct location by calling **ls** (as List Files), which will display all the files available in your current location. If you see the downloaded file, **download.sh**, you are in the right place. If not, you can check your current location in the line above (Fig. 4).

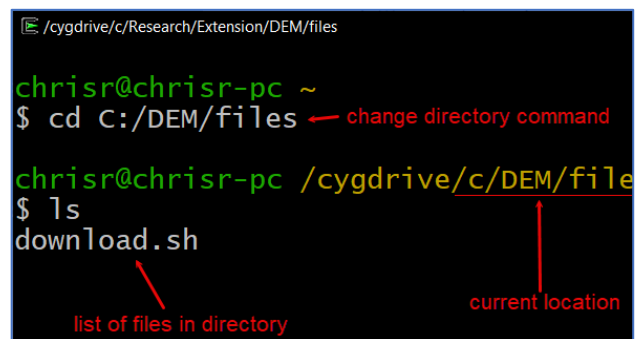


Fig. 4. In Unix-like terminal *cd* command changes directory and *ls* lists the available files.

- L. When you are in the correct directory, run the following command, (if you used a different name replace *download.sh* with the name of your script file):

```
chmod 777 download.sh
```

- M. Next, run the following command to start downloading all the files:

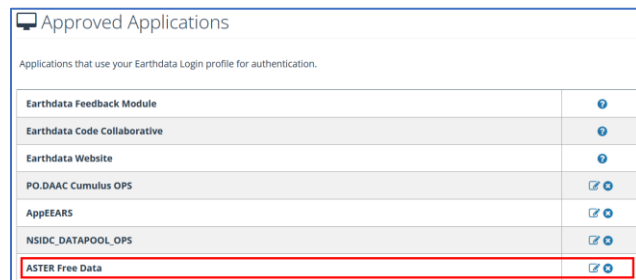
```
./download.sh
```

- N. You will be asked to login to Earthdata Search tool. Provide the login and password you set up with your account.
- O. The download process will start, and you will see rows displaying the size of the files downloaded and the time passed on downloading the data. If you head to the folder in *Explorer*, you will notice files are being downloaded to the location.

ERROR: Please ensure that you have authorized the remote application by visiting the link below

If you are seeing this information instead of a list of downloaded files, there might be two issues:

1. You have provided an **incorrect username and/or password**. Try again (you can recall the last command by pressing the upper arrow on the keyboard). Provide login credentials carefully.
2. If you have made sure that the information is correct but are still seeing the error, follow these steps:
 - a. Open the following link in your web browser: <https://urs.earthdata.nasa.gov/>.
 - b. Login to your account; this will open your Earthdata Profile website.
 - c. Click **Applications**, and then **Authorized Apps**.
 - d. Below the list that was displayed, click **APPROVE MORE APPLICATIONS** button.
 - e. Search for **ASTER**.
 - f. Next to **ASTER Free Data**, click **AUTHORIZE** button. After clicking, you will be returned to the list of authorized apps (Fig. 5).
 - g. Repeat the process for the remaining **ASTER** apps.
 - h. Once **ASTER** apps are authorized, go back to the terminal and rerun the download command.



Approved Applications	
Applications that use your Earthdata Login profile for authentication.	
Earthdata Feedback Module	Authorize
Earthdata Code Collaborative	Authorize
Earthdata Website	Authorize
PO.DAAC Cumulus OPS	Authorize
AppEARS	Authorize
NSIDC_DATAPOOL OPS	Authorize
ASTER Free Data	Authorize

Fig. 5. Many apps require prior authorization in user profile, before allowing external apps (like terminal) to download the data.

STEP 2. CREATING MERGED DEM

Once we have downloaded all the files, we need to merge them to make one large file. We can do this with any GIS software. Here we will present the process in QGIS and ArcGIS Pro.

STEP 2A. QGIS

For the QGIS software, complete the following steps:

- A. Open a new or existing project.
- B. In the menu panel, select **Raster**, then **Miscellaneous**, and in the new menu, select **Merge**.
- C. In the **Input Layers**, select the three-dot button at the end of the line.
- D. In the **Input layers manager** select **Add File(s)** and navigate to the location where you have downloaded all the DEM files from the first part of this tutorial. Note that some files are called **_dem.tif** and some **_num.tif**. We will be interested only in **_dem.tif** files.
- E. Use the **search files** tool to filter only DEM files by typing **_dem.tif**. This will limit the view to only the files we are interested in. Once the search is done, **select** all the **files** and click **OK**.
- F. You will be returned to the **Input layers manager**, where, in consecutive rows, the selected files are listed (Fig. 6). Make sure no **_num.tif** files are present, then click **OK**.
- G. In the main window, change the **Output data type** to **Int16**.
- H. Under **Merged** (or **Output** in some versions), click on the three-dot button and select **Save to file**. Navigate to the location where you want to save the output file and choose the file name.
- I. Verify that your **Input layers** show the correct number of files (same as when we started downloading the files in **Earthdata Search**) and that the **output** is being saved in the correct location. Finally, check the **Output data type**, and if everything is correct, click **Run** (this might take some time, depending on the speed of your computer).
- J. Once the process is finished, you will see one DEM file covering the entire state of Texas (Fig. 7).

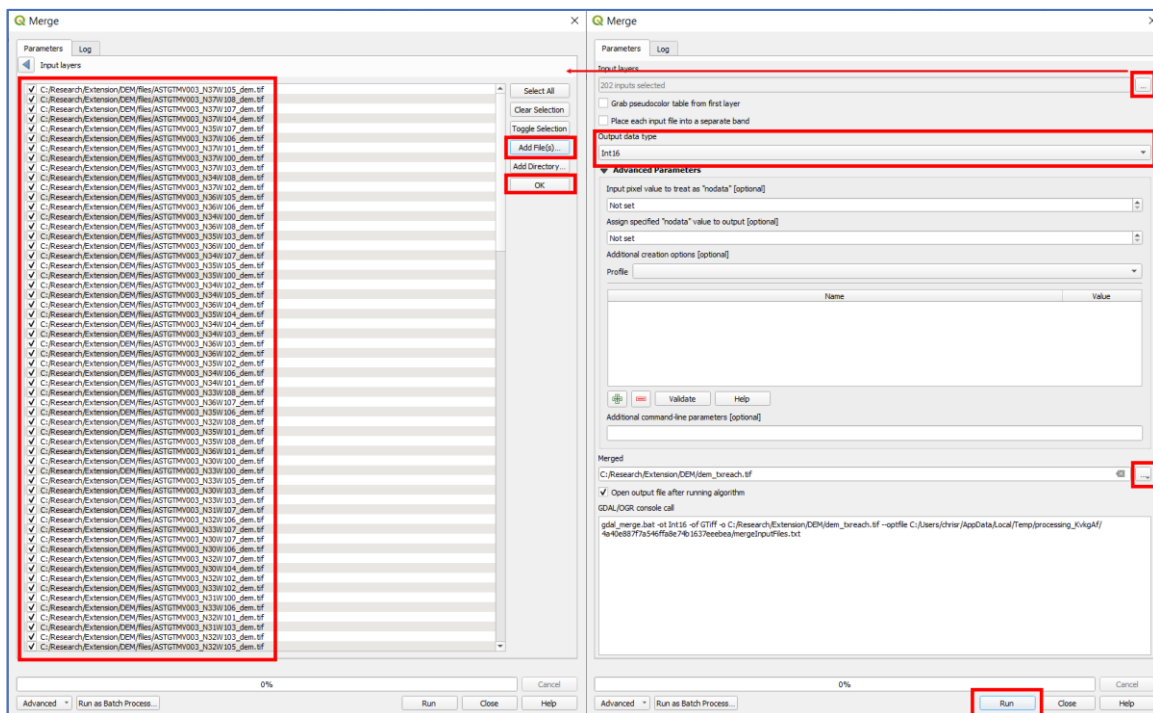


Fig. 6. Multiple settings are required in the Merge algorithm (QGIS) to prepare it for raster merging.

STEP 2B. ARCGIS PRO

For the ArcGIS Pro software, complete the following steps:

- A. Open a new or existing map project.
- B. In the menu panel, open **Analysis** tab and then **Tools** to open the **Geoprocessing** pane.
- C. Search for the **Mosaic To New Raster** tool, or open the **Data Management Tools** menu, then **Raster**, and finally **Raster Dataset** to display the available tools.

- D. In the **Mosaic To New Raster**, click the folder icon next to **Input Rasters** and navigate to the folder where the DEM files from the first part of this tutorial were downloaded.
- E. Choose all files that have a `_dem.tif` file ending. You can use the **Search** tool to limit the displayed items.
- F. In the **Output** options, set the destination folder and name of the file.
- G. Change the **Pixel Type** to **16-bit unsigned** and the **Number of Bands** to **1**.
- H. Once everything is set up, click **Run** to generate a new raster (Fig. 7).

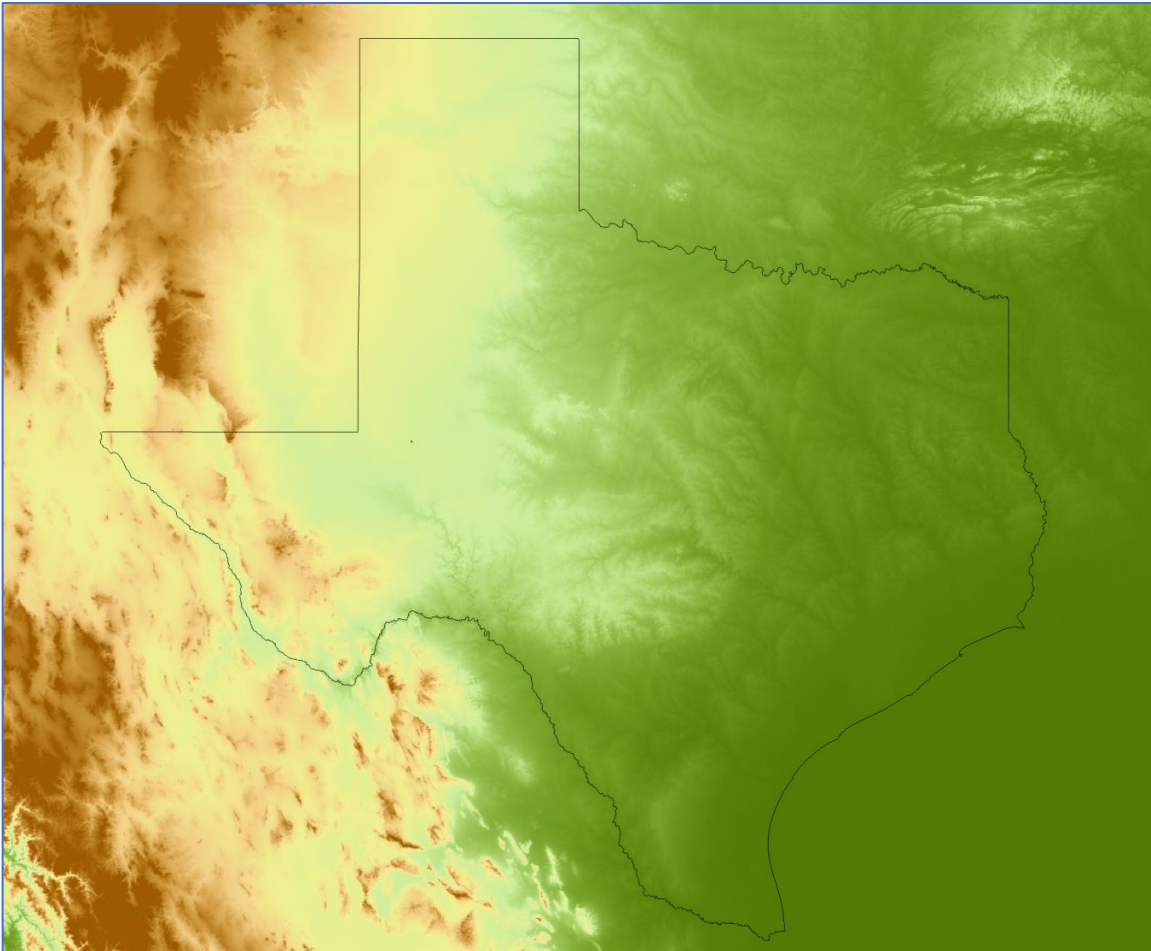


Fig. 7. Resulting, a single DEM output file.

We have reached the end of our GEO Tutorial on automated DEM data download using Earthdata Search and merging the files into a single output. You can use the concepts presented here to access and process different data available on the NASA website, including many of their satellite products. Don't be afraid to explore the available data on your own. If you experience problems downloading the files, remember to add the dataset to Authorized Apps in your user profile.