

Technical Details Updated GeoTREE Center Iowa LIDAR Data  
Dissemination Application

University of Northern Iowa Geoinformatics Training, Research,  
Education, and Extension Center

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Stewardship

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IOWA DEPARTMENT OF  
**AGRICULTURE &  
LAND STEWARDSHIP**

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## Brief User Guide

The University of Northern Iowa Geoinformatics Training Research Education and Extension (GeoTREE) Center has updated the old version of the Iowa LiDAR data dissemination application. The original version of that application was created approximately 15 years ago and was continuously updated and supported to deliver raw LiDAR and derived elevation products from the original statewide LiDAR data collection (~2010). Hundreds of terabytes of data were downloaded via that application by a variety of stakeholders from academia, private companies, government agencies, and many others. This new application builds upon that old application by adding access to the circa 2020 or more current LiDAR statewide data collection and by adding new modern data access mechanisms.

This document is meant to provide a brief overview of the application and how various data products may be utilized.

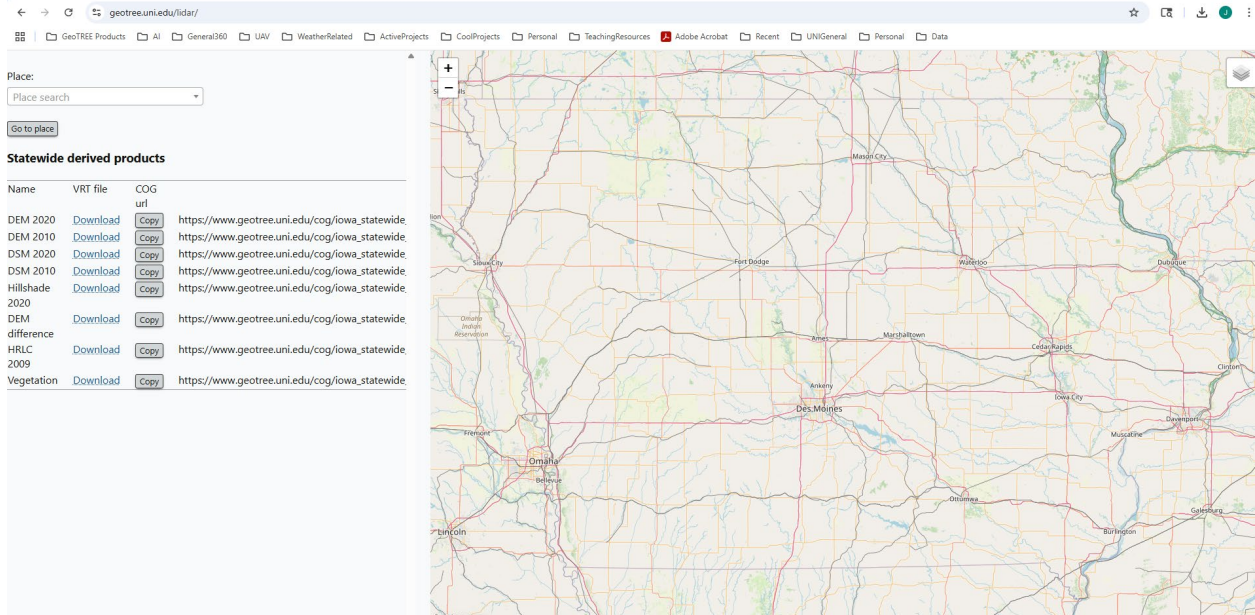
Questions can be directed to John DeGroot (Director, GeoTREE Center) at [john.degroot@uni.edu](mailto:john.degroot@uni.edu) or 319-273-6158 or Jonathan Voss at [Jonathan.voss@uni.edu](mailto:Jonathan.voss@uni.edu). Jonathan Voss was the developer of data processing algorithms and the web application itself.

At the new and updated <https://www.geotree.uni.edu/lidar/> you can access raw LiDAR data and multiple derived elevation and other geospatial products for the whole state through Virtual Raster Table (VRT, [story map on VRT](#)) or Cloud Optimized GeoTIFF (COG) formats. These formats provide a seamless way to display data for the whole state and also allow for geoprocessing or analysis for smaller sections study areas.

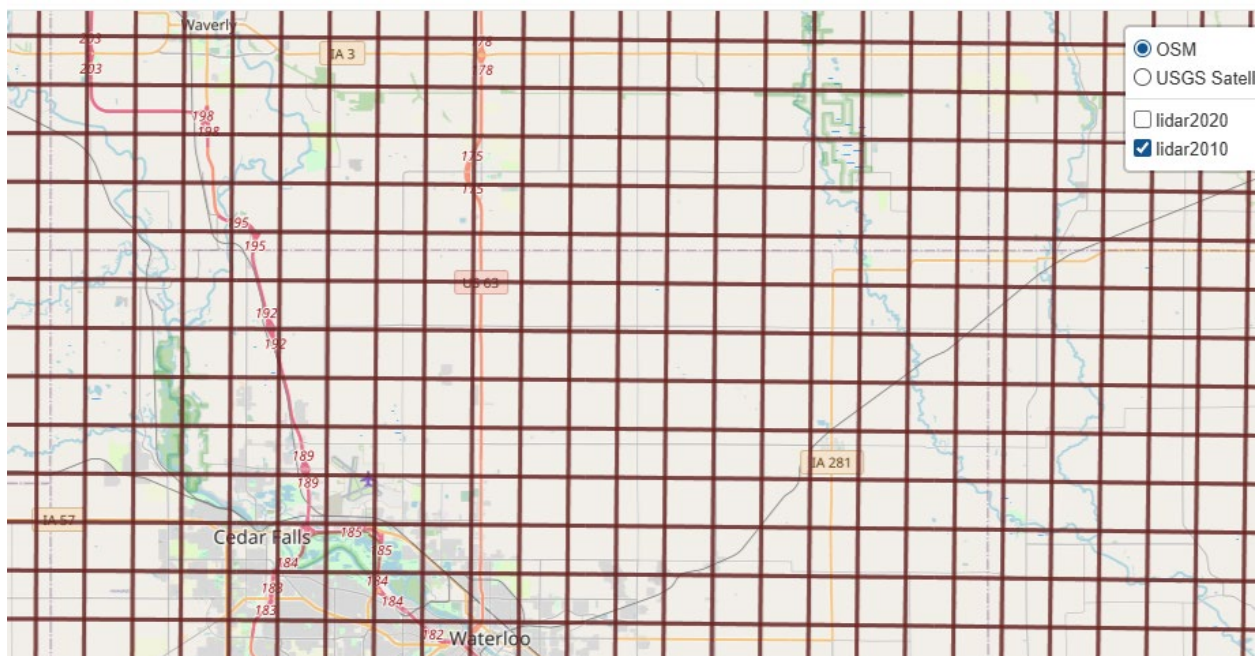
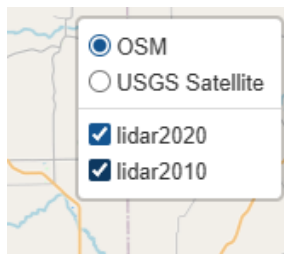
The brief instructions and screenshots below will demonstrate how to access the various datasets and briefly how to leverage/utilize in ArcGIS Pro and QGIS software for analysis or geoprocessing.

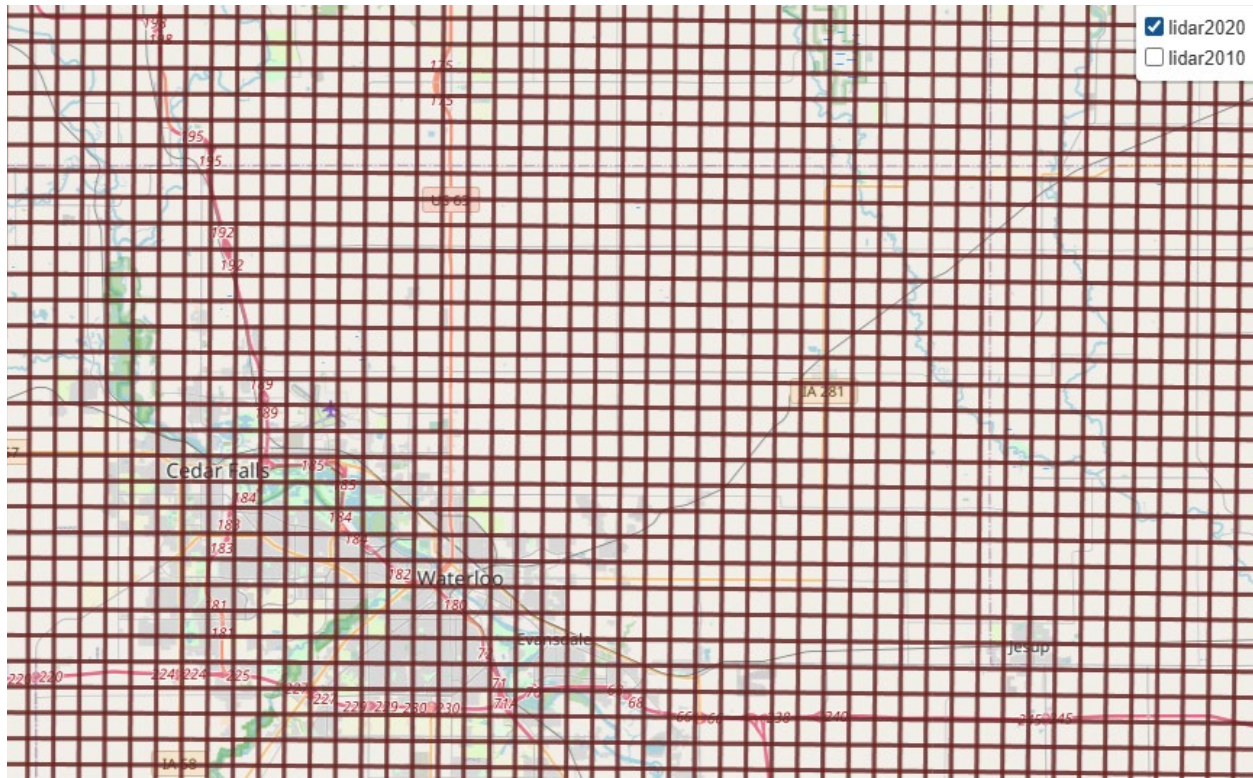
### Overall Interface

The overall user interface is shown below:



In the top right corner, the user can toggle the circa 2010 and 2020 LIDAR tile structure polygons on and off. The 2010 LiDAR tiles are a 2x2 km structure while 2020 is a 1x1 km structure. Note that those layers will only draw when zoomed in to something on the order of several county area.





In the Download Raw LiDAR Files section below there will be a description of how you can interact with these layers to download raw LiDAR data.

### Downloading Statewide Files

When the <https://www.geotree.uni.edu/lidar/> page is loaded there are 8 statewide VRT and COG links available. Each of the VRT links will allow you to download a statewide VRT for that given dataset which can be used in ArcGIS Pro directly. The COG URL (use Copy button) can be used to connect to the GeoTIFF data on the GeoTREE server via QGIS.

Brief metadata for each of the statewide datasets below are provided in Metadata section below. The DEM (Digital Elevation Model – bare earth) and DSM (Digital Surface Models – includes buildings/trees/etc.) were derived from the same raw LiDAR data that can be accessed via this site. The Hillshade raster provides a shaded relief raster based on the 2020 DEM. The DEM difference is basically just based on a subtraction per cell ( $DEM_{2020} - DEM_{2010}$ ). The HRLC 2009 VRT is based on the county downloads available [here](#). Finally the Vegetation raster was derived from LIDAR data and a Normalized Difference Vegetation Index (NDVI) raster derived from aerial imagery from the National Aerial Imagery Program.

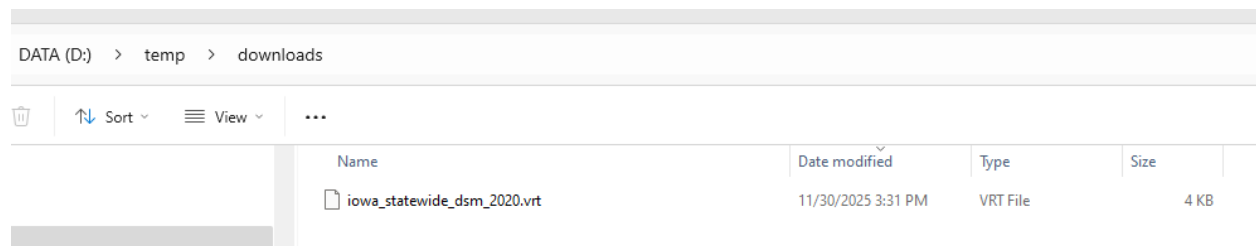
**WARNING:** Please read the metadata before using these data products. Also be aware that no efforts have been made at validation for these datasets. Specifically the Vegetation raster should likely only be used cautiously as there is of uncertainty in it's production. In the elevation derived products there are also gaps or missing areas over large water bodies.

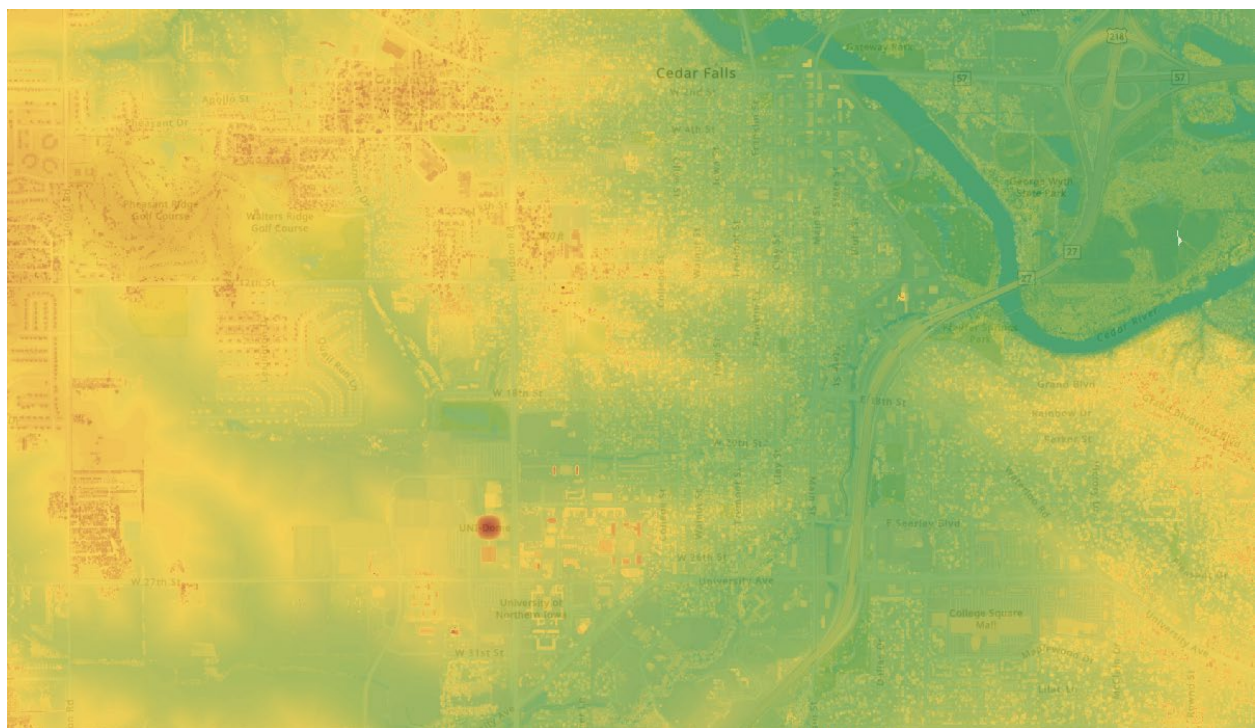
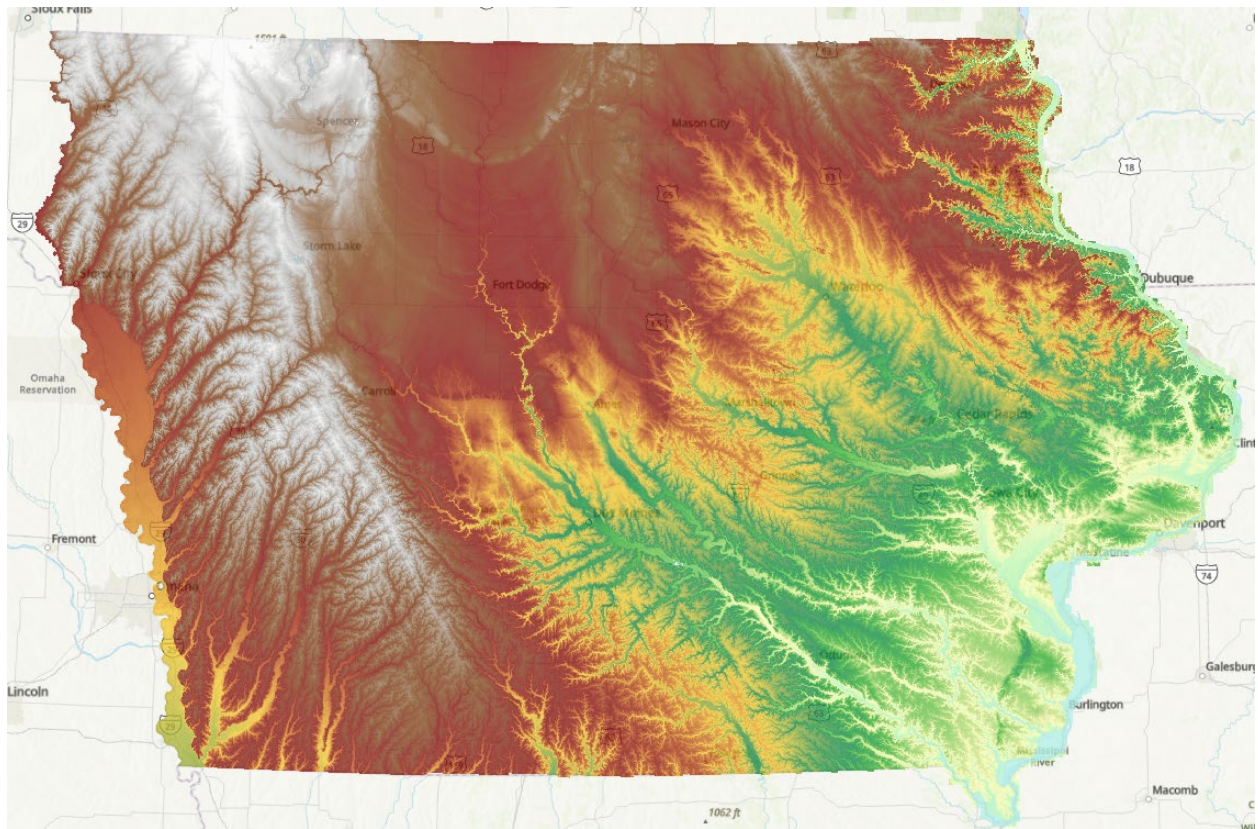
The GeoTREE Center welcomes suggestions for improving these data.

In the example screenshots below the 2020 DSM VRT is downloaded and added to ArcGIS Pro. The screenshots below show the file in Windows Explorer and then added to ArcGIS Pro. Note that the file itself is quite small (4 kb).

## Statewide derived products

Name	VRT file	COG url
DEM 2020	<a href="#">Download</a>	<a href="https://www.geotree.uni.edu/cog/iowa_statewide">Copy</a> https://www.geotree.uni.edu/cog/iowa_statewide.
DEM 2010	<a href="#">Download</a>	<a href="https://www.geotree.uni.edu/cog/iowa_statewide">Copy</a> https://www.geotree.uni.edu/cog/iowa_statewide.
<b>DSM 2020</b>	<a href="#">Download</a>	<a href="https://www.geotree.uni.edu/cog/iowa_statewide">Copy</a> https://www.geotree.uni.edu/cog/iowa_statewide.
DSM 2010	<a href="#">Download</a>	<a href="https://www.geotree.uni.edu/cog/iowa_statewide">Copy</a> https://www.geotree.uni.edu/cog/iowa_statewide.
Hillshade 2020	<a href="#">Download</a>	<a href="https://www.geotree.uni.edu/cog/iowa_statewide">Copy</a> https://www.geotree.uni.edu/cog/iowa_statewide.
DEM difference	<a href="#">Download</a>	<a href="https://www.geotree.uni.edu/cog/iowa_statewide">Copy</a> https://www.geotree.uni.edu/cog/iowa_statewide.
HRLC 2009	<a href="#">Download</a>	<a href="https://www.geotree.uni.edu/cog/iowa_statewide">Copy</a> https://www.geotree.uni.edu/cog/iowa_statewide.
Vegetation	<a href="#">Download</a>	<a href="https://www.geotree.uni.edu/cog/iowa_statewide">Copy</a> https://www.geotree.uni.edu/cog/iowa_statewide.





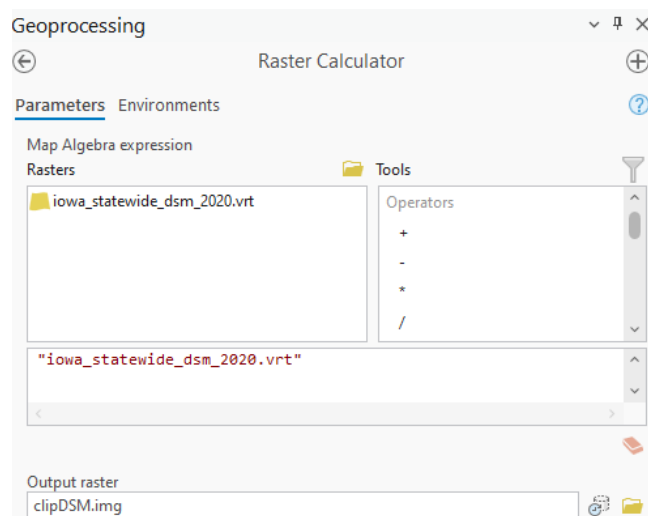
### Geoprocessing VRT data in ArcGIS Pro

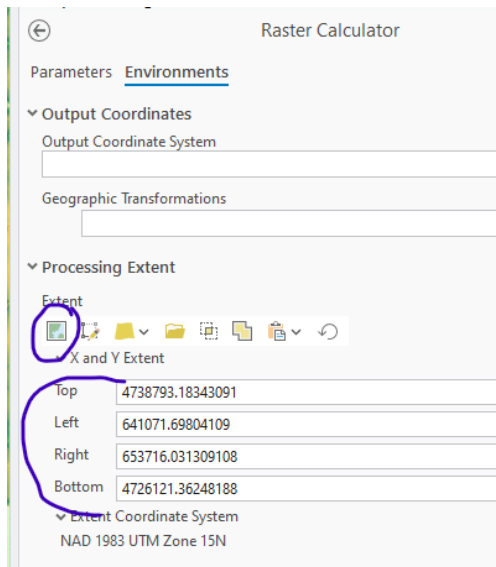
Beyond just visualizing the data, when you have the statewide VRT in ArcGIS Pro you can carry out geoprocessing and analysis. However, be aware that this is a very large dataset being accessed on the

server (see screenshot below). Thus if you try to carry out some geoprocessing/analysis statewide or for a very large area it likely will not work.

▼ Raster Information	
Columns	538000
Rows	356000
Number of Bands	1
Cell Size X	1
Cell Size Y	1
Uncompressed Size	713.50 GB
Format	VRT

However, you can make local copies or do some more localized analysis. The key step is to use Environment Settings to restrict the area being processed. So, in the example below the Raster Calculator tool is used to make a copy of the DSM VRT but for only the current display extent (set in Environments dialog – second screenshot).

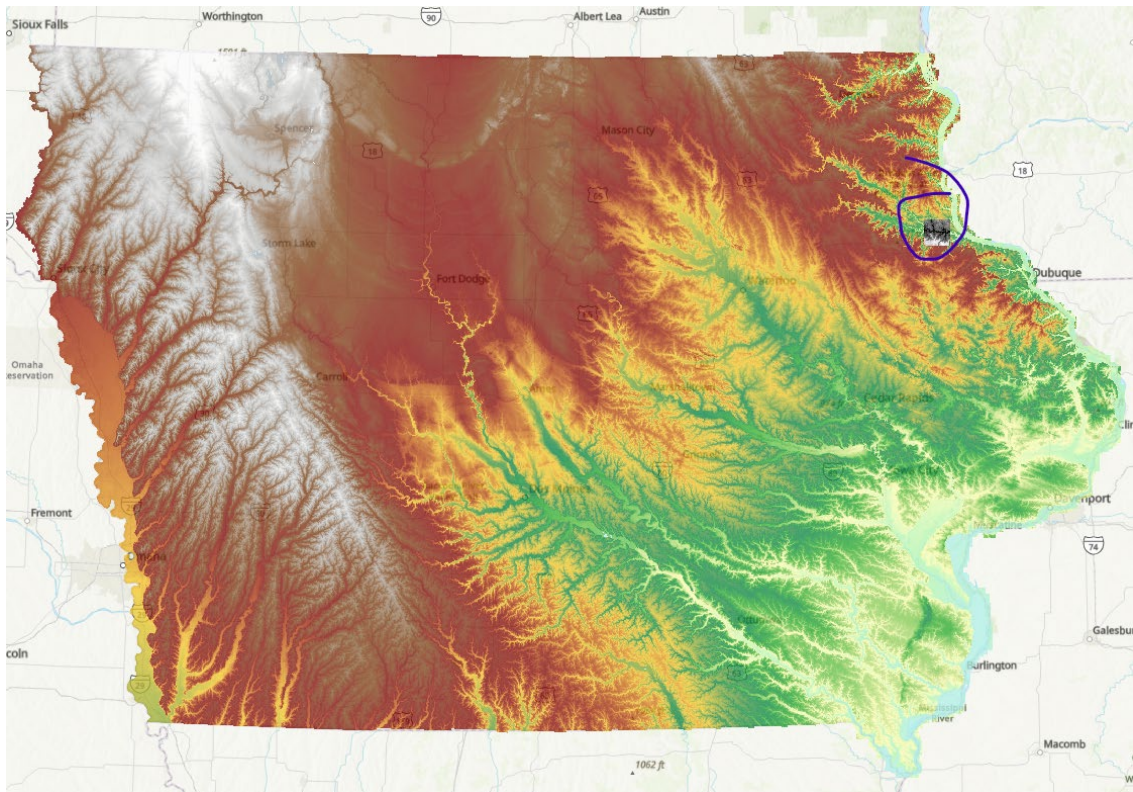
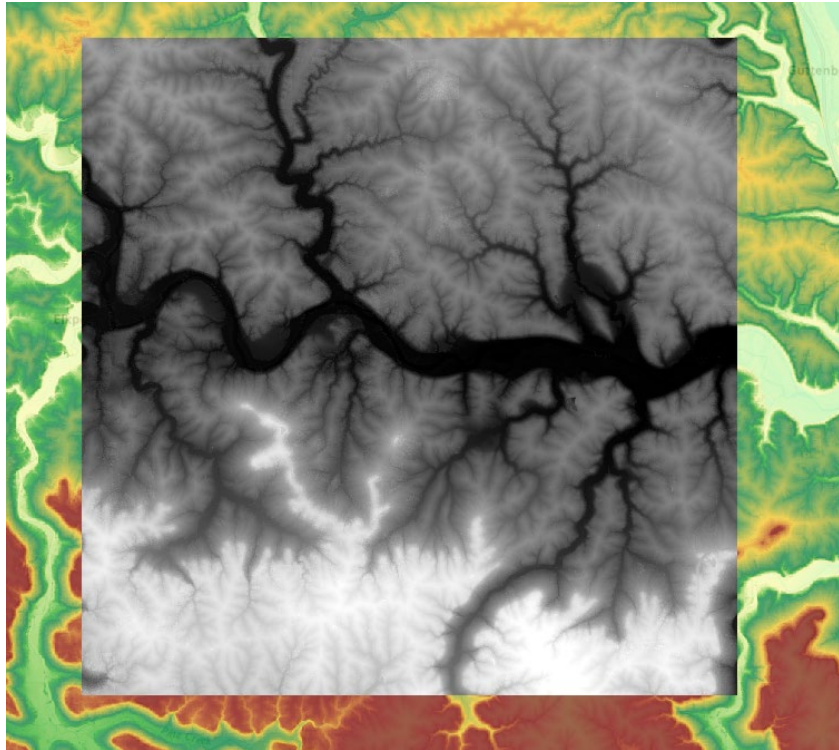




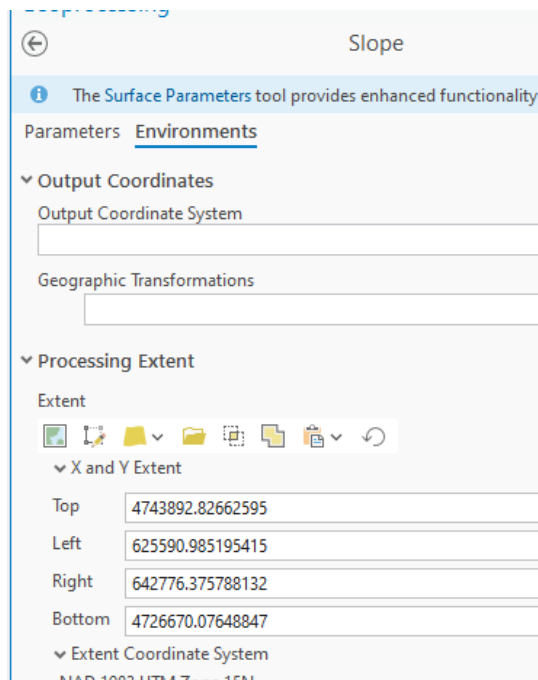
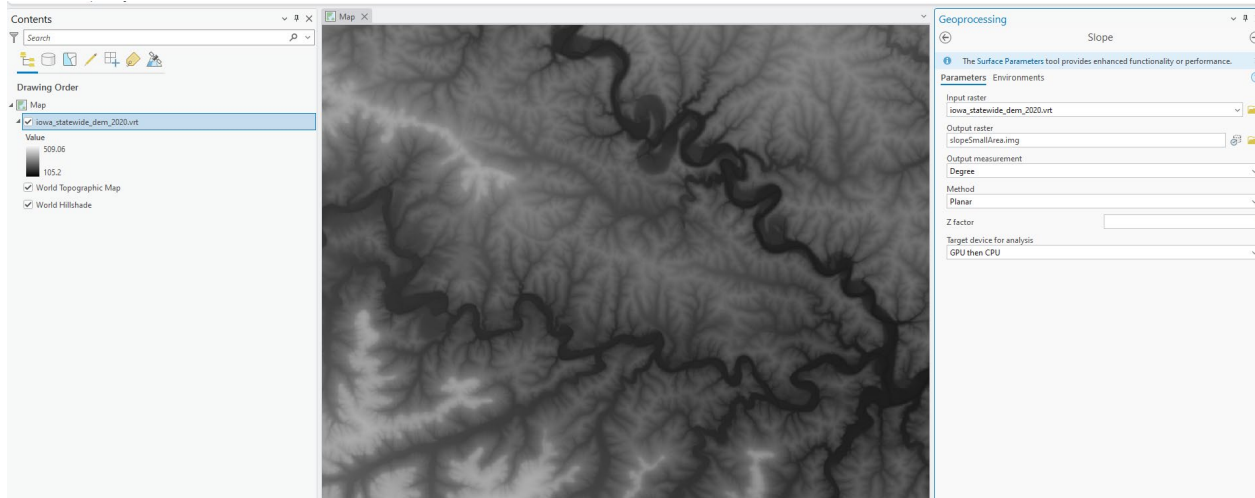
Clipping that DSM out in ArcGIS Pro took approximately 30 seconds and produced a 611 megabyte .img file on the local machine. Below are some screenshots demonstrating the output raster information and displayed in ArcGIS Pro.

#### ▼ Raster Information

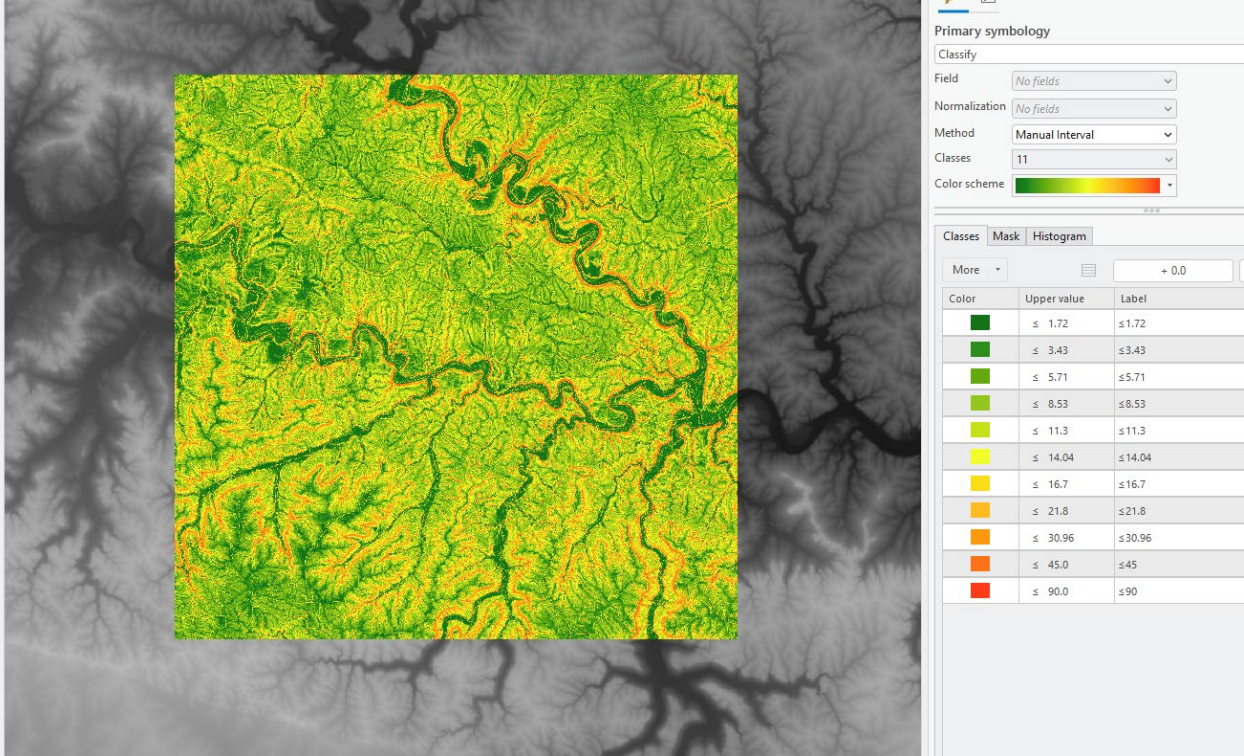
Columns	12644
Rows	12672
Number of Bands	1
Cell Size X	1
Cell Size Y	1
Uncompressed Size	611.21 MB



In another example, below the Slope (Spatial Analyst) tool is run on current display extent on the statewide 2020 DEM.



This tool took about 1 minute to run on this small area of the state and produced an .img raster dataset locally which is 1.1 GB in size.

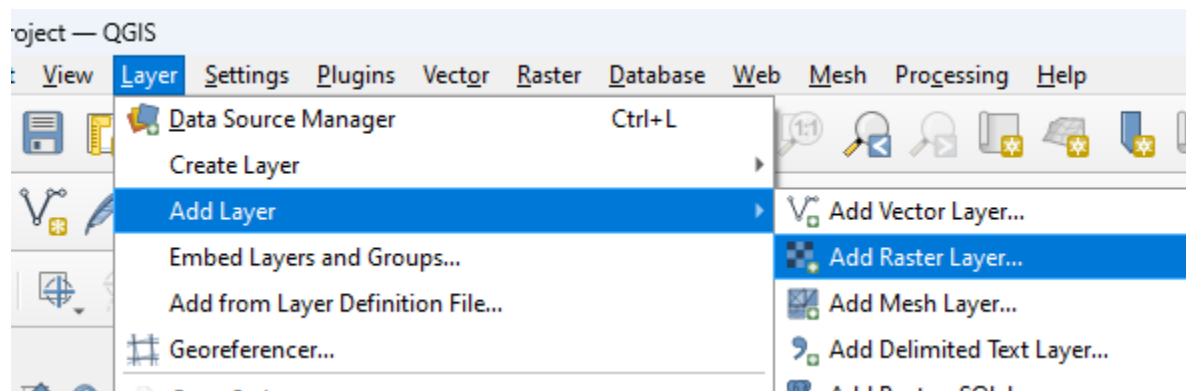
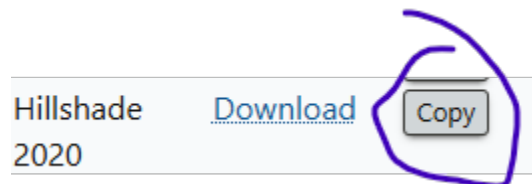


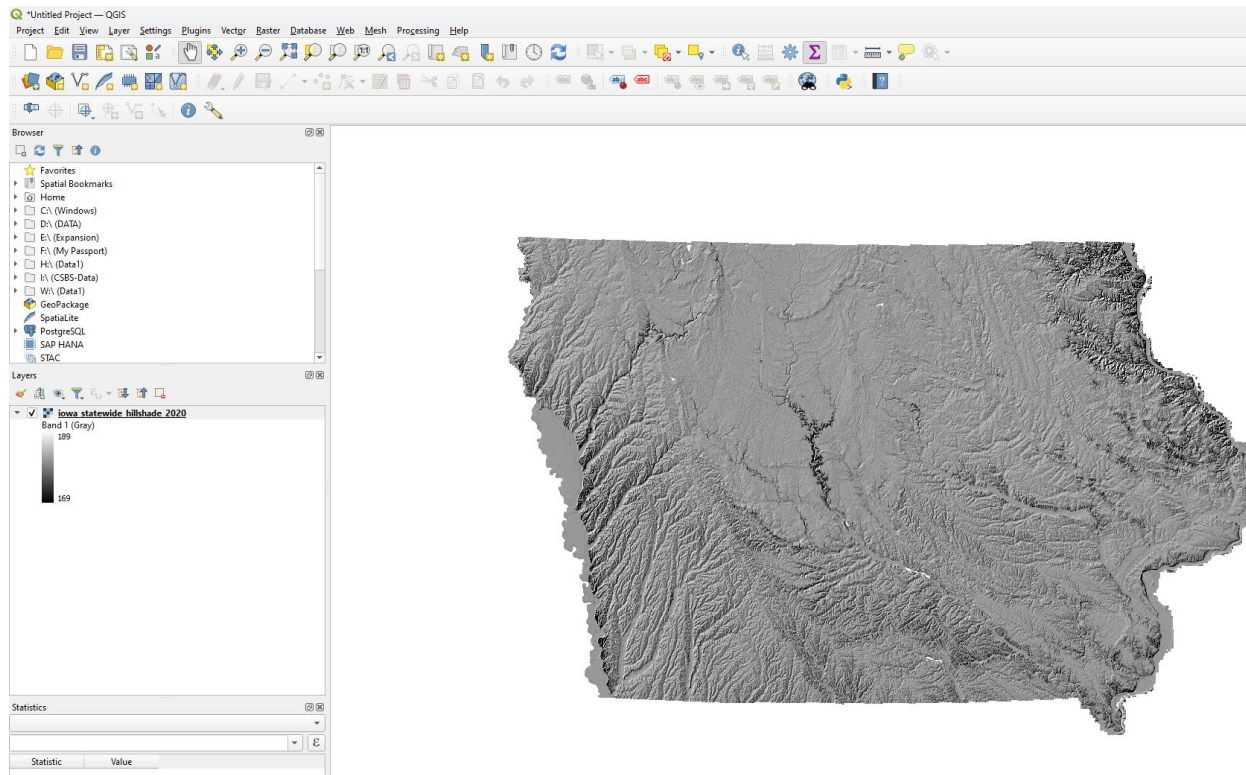
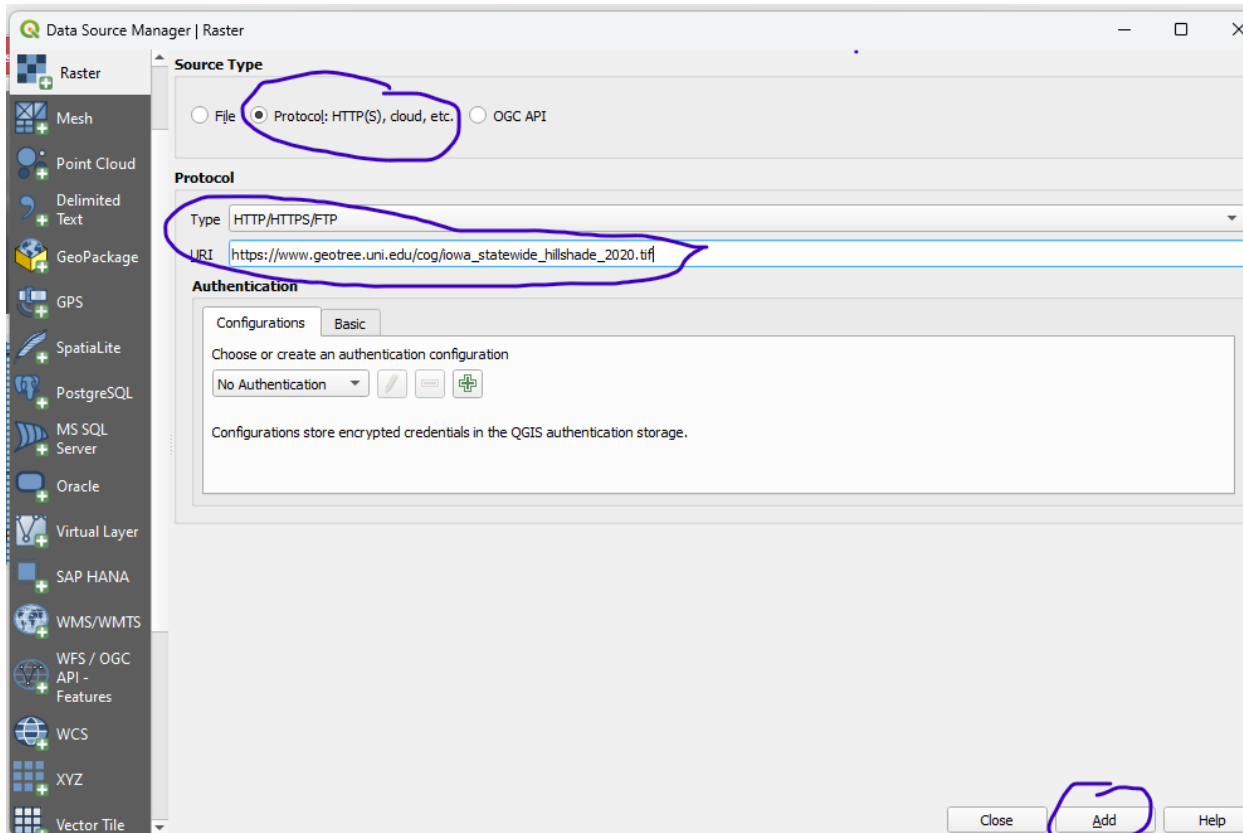
### ▼ Raster Information

Columns	17185
Rows	17223
Number of Bands	1
Cell Size X	1
Cell Size Y	1
Uncompressed Size	1.10 GB
Format	IMAGINE Image

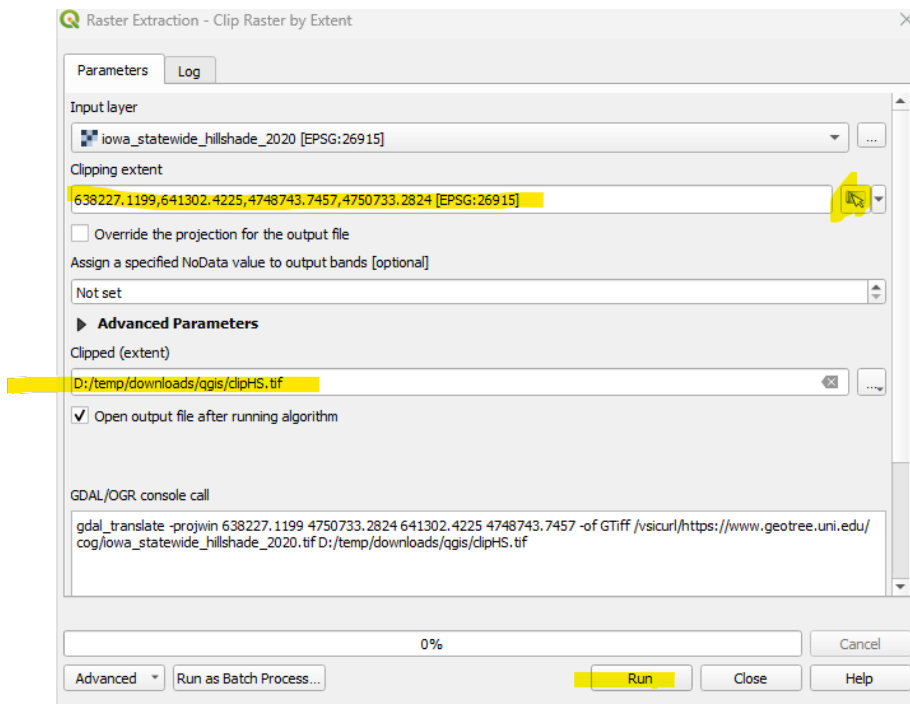
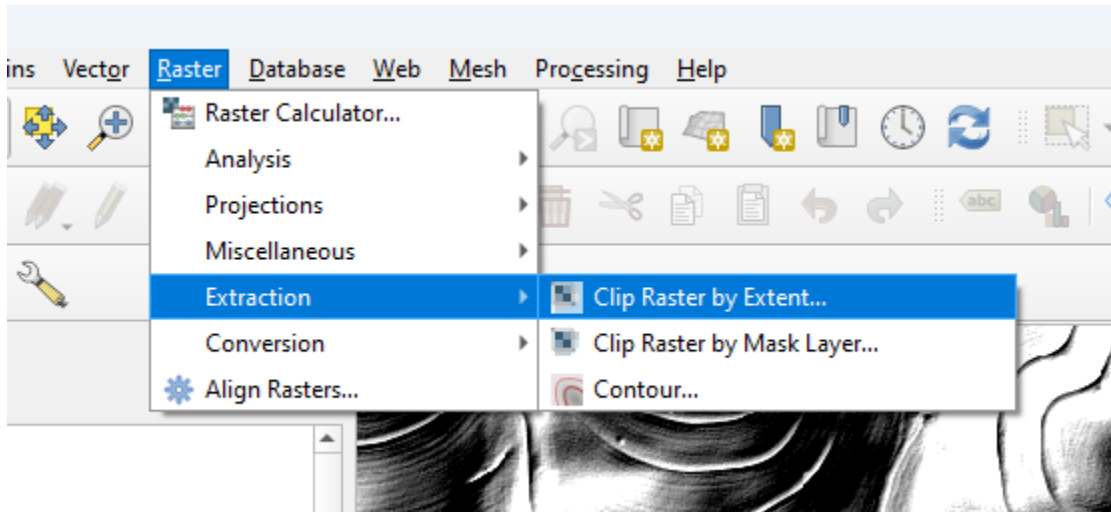
### Connect to COG in QGIS

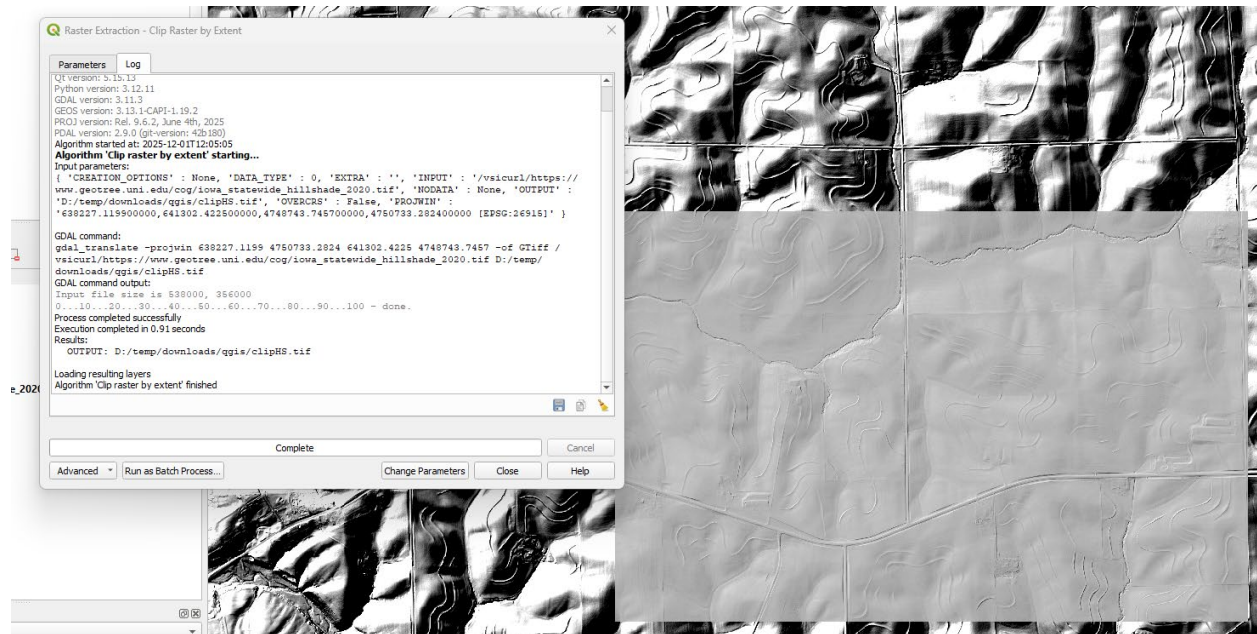
You can add the URL's from <https://www.geotree.uni.edu/lidar/> to a connection in QGIS to leverage the statewide datasets similar to the ArcGIS Pro examples above with the VRT files. The screenshots below demonstrate connecting to the 2020 Hillshade raster. So first the Copy button is clicked. In QGIS choose Layer – Add Layer – Add Raster Layer. And then set as seen below





The Cloud Optimized GeoTIFF data can then be used in QGIS for geoprocessing or analysis. In example below the Raster Calculator is used to make a clipped copy of the hillshade raster for the present map view or Map Canvas Extent.

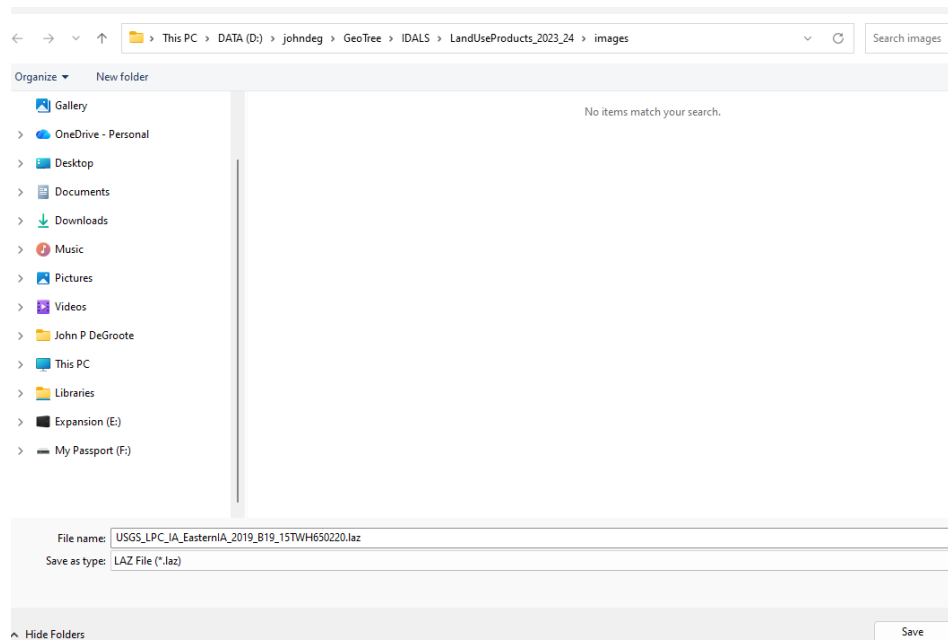




## Download Raw LiDAR files

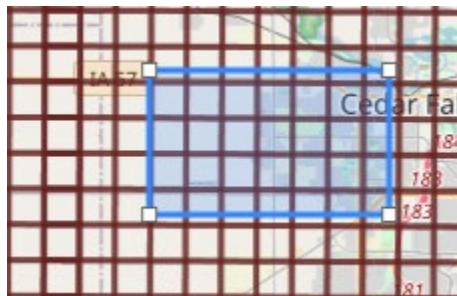
Clicking on a tile polygon in the the 2010 layer brings up links to the XYZI and LAS files for the given tile. While clicking on a tile polygon in the 2020 layer there will be a link for the .laz file and the associated metadata link both (via the USGS servers). If you click on the LAS File, XYZI File or Tile (for 2020) it should open your file system's save dialog.



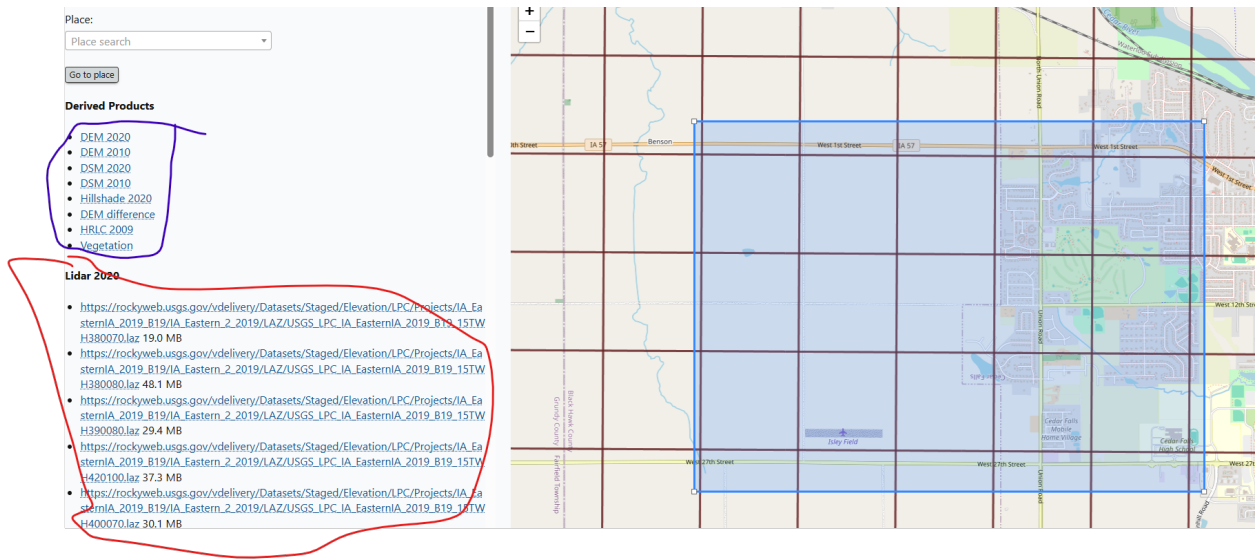


## Select a set of tiles by drawing an Area of Interest

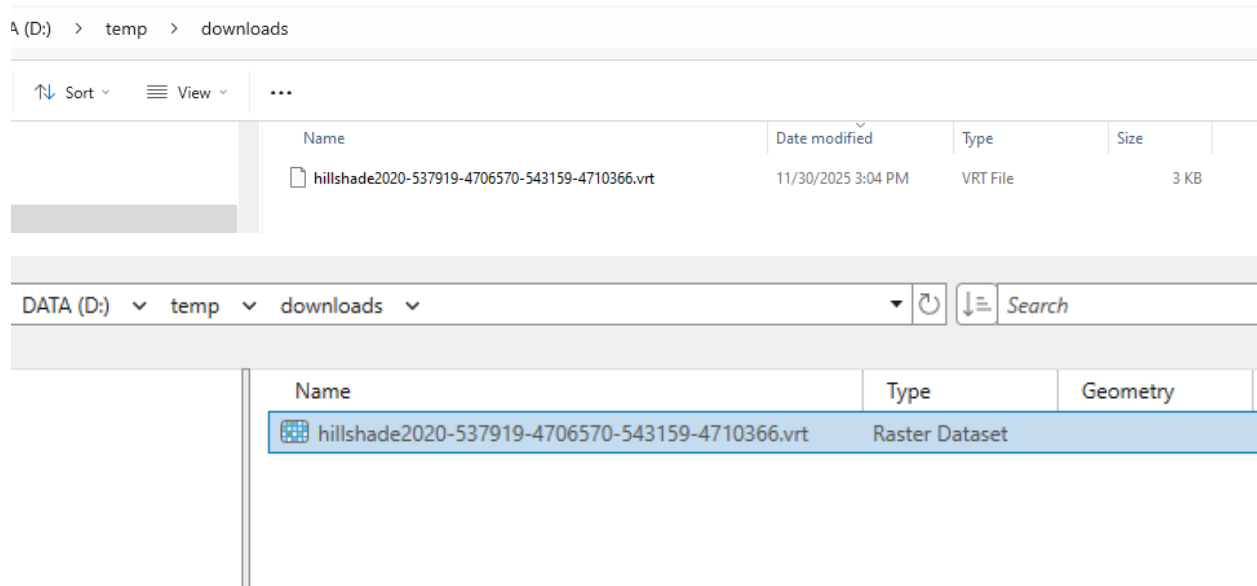
If you click on the Select LiDAR button in the bottom left corner of the map interface you can then draw a rectangle to select a set of tiles.

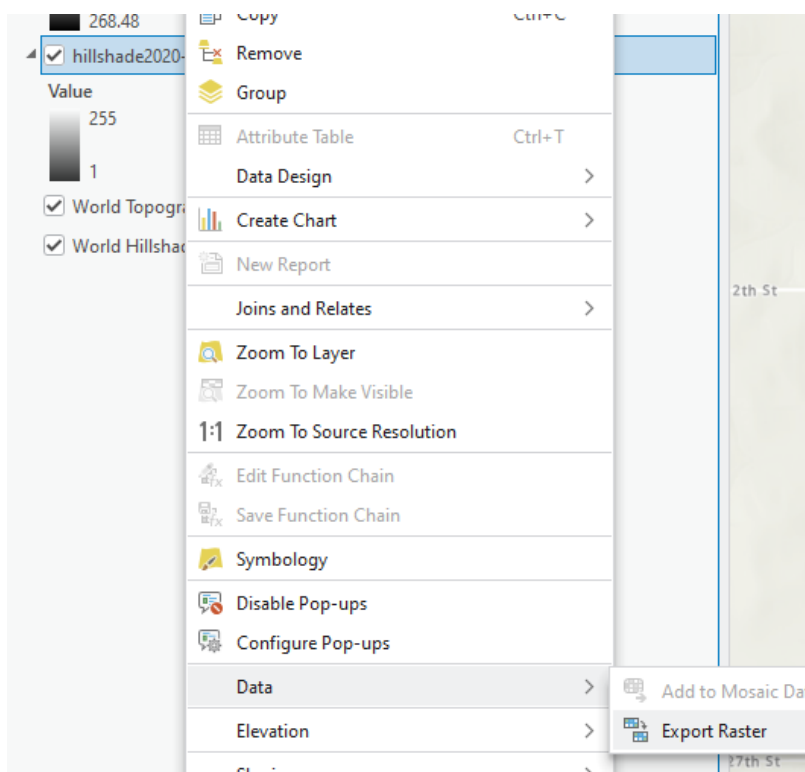
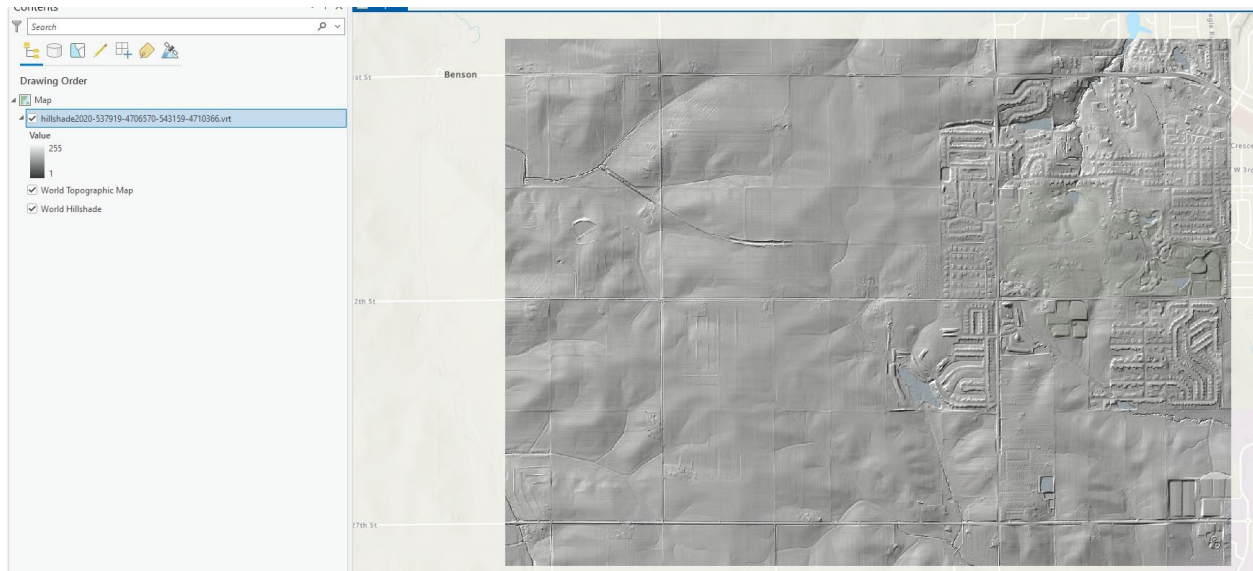


Once that rectangle is drawn the application will create a list of potential downloadable files and populate in the left panel. At the top will be a list of clipped VRT files (circled in blue) for each of the derived statewide data products. Below that will be a list of raw LiDAR files from both 2010 (XYZI and LAS) and 2020 (.laz).



In the screenshots below the 2020 Hillshade raster for the selected area is shown in Windows Explorer and added to ArcGIS Pro. Note that this VRT file is very small as it is just referencing the actual data on the GeoTREE Server. However, this VRT layer can be used to carry out analysis or geoprocessing or can just be exported directly to a local raster format (e.g. .tif, .img, etc.).





Select a set of tiles by searching for an administrative geographical unit

When <https://www.geotree.uni.edu/lidar/> is loaded you can search for a place by beginning to type a city or county name (or some other place). Then when you click the Go to Place button it will do the same as the Select LiDAR tool above – i.e. generate a list of URL's for clipped derived products from the statewide datasets and a list of URL's for 2010 and 2020 raw LiDAR products.

Place:

Place search

- Marshalltown (City)
- Marshall (County)
- Marsh (Unincorporated)
- Marshall (Unincorporated)

Place:

Marshalltown (City)

Go to place

## Marshalltown

### Derived Products

- [DEM 2020](#)
- [DEM 2010](#)
- [DSM 2020](#)
- [DSM 2010](#)
- [Hillshade 2020](#)
- [DEM difference](#)
- [HRLC 2009](#)
- [Vegetation](#)

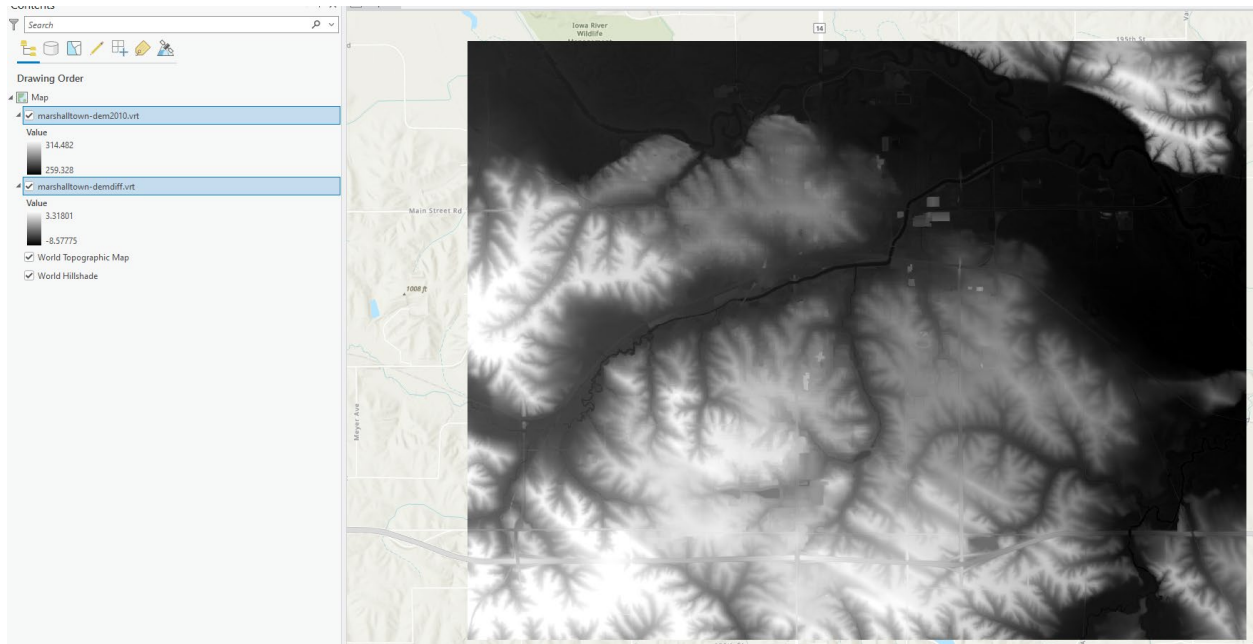
### Lidar 2020

- [https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/LPC/Projects/IA\\_NorthCentral\\_2020\\_D20/IA\\_NorthCentral\\_2\\_2020/LAZ/USGS\\_LPC\\_IA\\_NorthCentral\\_2020\\_D20\\_w5050n4649.laz](https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/LPC/Projects/IA_NorthCentral_2020_D20/IA_NorthCentral_2_2020/LAZ/USGS_LPC_IA_NorthCentral_2020_D20_w5050n4649.laz) 46.3 MB
- [https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/LPC/Projects/IA\\_N](https://rockyweb.usgs.gov/vdelivery/Datasets/Staged/Elevation/LPC/Projects/IA_N)

## .idar 2010 (las)

- <https://www.geotree.uni.edu/lowaLidar/05104654.las.7z> 25.3 MB
- <https://www.geotree.uni.edu/lowaLidar/05024654.las.7z> 30.5 MB
- <https://www.geotree.uni.edu/lowaLidar/05024650.las.7z> 31.5 MB
- <https://www.geotree.uni.edu/lowaLidar/05104650.las.7z> 27.4 MB

The screenshot below shows the clipped Marshalltown 2010 DEM VRT in ArcGIS Pro.



## Metadata

Below brief information about geoprocessing that took place to produce the derived products is provided.

In general, most, but not all, are derived data products from the raw LIDAR data either from 2010 or 2020. The USGS provides metadata per tile for the 2020 raw LiDAR data. A metadata link per tile can be found by click on a 2020 tile at the web application. An [example](#) can be seen here.

Generally, Jonathan Voss used Python to run tools from GDAL and PDAL to process the raw LiDAR data.

### DEM 2020

- Spatial resolution: 1 m

- PDAL [filters.range](#) is used to create a temporary raster
  - Only include points classified as ground (class 2)
  - Exclude points with overlap and withheld classification flags
- GDAL Inverse Distance Weighted is used to fill any small gaps using a 3x3 window with the minimum value applied
- A [GDAL writer](#) is used to create the raster dataset
- Then the remaining no data pixels are filled with `gdal_fillnodata.py` with a distance of 100 and smoothing of 2

#### DSM 2020

- Spatial resolution: 1 m
- PDAL [filters.range](#) is used to create a temporary raster
  - Include Classifications: [0:6],[8:17],[19:] (This excludes 7 and 18 which are low noise and high noise).
  - Exclude points with overlap and withheld classification flags
- GDAL Inverse Distance Weighted is used to fill any small gaps using a 3x3 window with the mean value applied
- A [GDAL writer](#) is used to create the raster dataset
- Then the remaining no data pixels are filled with `gdal_fillnodata.py` with a distance of 100 and smoothing of 2

This DSM was used in the solar radiation modeling project carried out by the GeoTREE Center and funded by the Iowa Economic Development Authority Iowa Energy Center. That project can be found [here](#) and from there you can access both the DSM VRT and Solar Radiation VRT files.

#### DEM 2010

- Spatial resolution: 1.5 m
- PDAL [filters.range](#) is used to create a temporary raster
  - Only include points classified as ground (class 2)
  - Exclude points with overlap and withheld classification flags
- GDAL Inverse Distance Weighted is used to fill any small gaps using a 3x3 window with the minimum value applied
- A [GDAL writer](#) is used to create the raster dataset
- Then the remaining no data pixels are filled with `gdal_fillnodata.py` with a distance of 100 and smoothing of 2

#### DSM 2010

This DSM raster was created as part of a previous project the Iowa Economic Development Authority funded to carry out solar radiation modeling. That project was superseded by the project mentioned above and described [here](#).

The processing was built into a Python and arcpy script and spread across many computers following roughly the following workflow:

- Download raw LiDAR data in .las format
- Carry out a check on each LiDAR tile to look for outlier or spurious points. These types of points results from things like the lasers hitting birds during LiDAR data collection but also from some systematic problem in the .las data. This step was necessary to clean these points up so they would not affect subsequent processing.
- Convert .las LiDAR data to multipoint feature class
- Create a digital surface model raster from multipoint feature class using Inverse Distance Weighting tool in ArcGIS Pro 3D Analyst using the following code
  - `arcpy.Idw_3d('in_memory\\points', 'Shape.Z', demFC, '1.5', '2', 'VARIABLE 3', '')`

#### DEM Difference (DEM 2020 – DEM 2010)

Each tile from the 2010 DEM is resampled from 1.5 to 1 meter using bilinear resampling. The extent is clipped out of the 2020 DEM. The two files have the exact same number of pixels and same area, and then a tile is written by subtracting each pixel in one tile from the same pixel in the other.

#### HRLC 2009

A statewide VRT was created from the county downloads raster files downloaded from [here](#)

#### Vegetation

This VRT was created in a multistep process below with the goal to isolate vegetation that might fall in the shrub/tree height range. The first two points were carried out using Python/arcpy scripts and ArcGIS Pro raster algebra steps per county.

- Automated download of county 2021 NAIP CIR imagery from [geodata.iowa.gov](http://geodata.iowa.gov)
- Calculation of Normalized Difference Vegetation Index (NDVI) - see formula at
- A statewide VRT of NDVI was created
- Using DEM 2020, DSM 2020, and the statewide NDVI and the `gdal_calc` function was used with the following equation
  - $(N \geq 0.0) * (((S - T) \geq 3.5) * ((S - T) < 12) * (-251) + (((S - T) \geq 12) * (-250))) + 255$
  - N is the NDVI value, T is the DTM value, and S is the DSM value
- The logic is if the NDVI value is > 0 it indicates it may be vegetation and then from 3.5 m to 12 is considered medium height vegetation and higher than 12 m is considered high vegetation
  - All other cells are given a value of NoData

