CAPSTONE LOGBOOK

Palouse Precision Agriculture in Virtual Reality

JANUARY 30, 2020

UNIVERSITY OF IDAHO
Damon E Schafer

Feb. 7, 2020

Attended the first group meeting. Communications were set up via discord, and all team members were granted access. We set up a common meeting time to meet weekly on Fridays in the library. Discussed important details about the project, setting up a meeting with our sponsor, team contract, logbooks, and other general information.

Feb. 11, 2020

Sent an email requesting a meeting with our project sponsor Dev Shrestha.

> Dear Mr. Shrestha,
>
> Hello, my name is Damon Schafer and I am part of the Capstone group assigned to work with you on the project you outlined on January 23. My team and I are interested in learning more about the project so we can be better prepared moving forward. Is it possible to arrange a meeting with you so we can discuss formal details regarding this project? We are flexible with meeting times, so please let me know about what time works for you. I look forward to hearing from you.
>
> Sincerely,
>
> Damon E Schafer

Feb. 14, 2020

Had a preliminary meeting with Dev Shrestha to learn about some formal details about the project. We discussed the location of the lab where equipment is located to help us with the project, additional meetings and meeting frequency, online repositories, reporting of progress, and more details about the problems needing to be solved. More specifically, we discussed two main problems. The first on to be solved is optimizations based on different criteria on the path travelled of a tractor. The other problem is concerned with interpolation to create more smooth representations of the fields and terrain.

Feb. 18, 2020

Began looking at the documentation of the project in the online repository. Began looking at the problem to be solved. Sent an email to our sponsor about obtaining keycode access to the lab so we could gain access to farming simulator and work on the project.

Feb. 21, 2020

Minutes - Friday, February 21st, 2020

2:00pm - 3:10pm

Meeting participants

Conrad Mearns, Joshua Dempsey

Amendments to previous Minutes

None

Agenda Items

- Draft the team contract

Actions taken

- Drafted team contract

Next steps

- Conrad to finalize contract prose for final draft
- Damon to edit contract draft in lieu of absence
- Contract to be sent to Bolden

No Votes

No Motions

No items held over

New business

- Sign final draft of the contract
- Review previous team's project resources

Next meeting

- Fri 26, 2pm, Library

I could not attend this meeting due to a prearranged absence.

Feb 22, 2020

Began reading the book *Farming Simulator Modding for Dummies* provided in the online repository. Worked through ch.1, ch2

- Downloaded the GIANTS editor. This is the editor and game engine used to create and/or mod Farming Simulator 2019.
- Farming Simulator is required to use the editor to edit existing maps and content
- Four panels in the editor covered: Scenegraph, 3D Viewport, Attributes, Scripting.
- The editor used the .I3D format for assets and models
- Map is a collection of 3D assets
- Covered navigating the 3D environment
- Covered how to transform an object: translation, rotation, and scaling
- Covered steps on how to create a new map mod
    - There is a dedicated mods folder
- Described the steps to create a new map and edit/add assets
    - Importing external assets
    - Creating a transform group
    - Mass duplication of objects
    - Adjusting user attributes
        - Can adjust field properties, may be useful later
    - Covered triggers to execute events

Feb 26, 2020

Worked through ch.3 of the modding book.

- Began working on a tutorial that covers how to change the topography of the map.
    - Will be useful later on in the project
- Select Terrain editing tool
    - Using the terrain brush
- Can enable noise when editing to incorporate an element of randomness with the appearance of the terrain.

    - Can change the seed used
    - Persistence, or strength, of the noise can be edited as well
    - Adding surface erosion – IMPORTANT
    - "Erosion settings only work on the Add brush behavior"
        - May cause issues later?
    - Thermal vs. Hydraulic erosion
    - Thermal is what we would be more interested in. It is concerned with "how dirt and rock break lose over time and slide down a slope to form a pile at the bottom"
    - Foliage channels exist, 0-6
        - 0: Cultivated land
        - 1: Ploughed Land
        - 2: Seeded/Planted Land
        - 3: Seeded/Planted Potatoes
            - Interesting that potatoes get their own dedicated layer
    - Different foliage channels should be used for different types of crops as well. A chart is provided on page 49.
    - Navigation mesh is a special geometry on the map where a type of animal can move within.
- Since animals are not the focus on this project, the rest of the sections covering this were skipped.

Mar. 1, 2020

Began reading and working through chapter 4. In the book and following with the GIANTS editor when possible.

- Material: collection of textures and attributes that define the collection
- A 3D object can have up to 8 materials defined for it
- Can edit properties of the collection

Mar. 3, 2020

Minutes - Tuesday, March 3rd, 2020

3:39pm – 4:10pm

Meeting participants

Conrad Mearns, Joshua Dempsey, Damon Schafer

Amendments to previous Minutes

None

Agenda Items

- Sign final draft of the contract
- Name decision: Dev's Devs

No Votes

No Motions

Items held over

- Review previous team's project resources

New business

- Wikipedia / Knowledgebase
- Review Farming Simulator Terrain API

Next meeting

- Tue 10, 3:30pm, One World

Mar. 10, 2020

We were supposed to meet today. However, due to my location being off campus, I did not have the chance to get into Moscow for the meeting, so we decided not to meet.

Mar. 13, 2020

Worked through chapter 5 in the book. Covers the use of particles.

- Skimmed through the section as particles do no benefit the purpose of the project.

Mar. 15, 2020

Worked through chapter 6 in the book. Covers how to set up a mod.

- Certain details about the mod need to be described in a modeDesc.xml file
    - All mods need one of these files
    - <author> person who made the mod
    - <title> name of the mod
    - <version> version of the mod
    - <description> descript. Of the mod
    - <iconFilename> path to an image as the icon for the mod
    - <multiplayer> does the mod work in multiplayer
- The mod also needs to be visible to the in game store.
    - <storeItems> tag used for this
    -

Mar. 18, 2020

Mar. 20, 2020

Mar. 24, 2020

Met with the team today virtually through Zoom. Covered the following points:

- Create a group tasks document located at:
    - https://vandalsuidaho-my.sharepoint.com/:w:/g/personal/mear8979_vandals_uidaho_edu/EXKctoHjFzdJswLFE20oYLAB_G4Zn6EGHCxGO92y5qiRpQ?rtime=0nRB0lXw10g
- Created a central location for all the important links for the capstone project.
- Discusses the goals for the project.
    - Map interpolation
    - Path finding algorithm for optimization
        - Fuel optimized
        - Erosion optimized
        - Time optimized

Mar. 24, 2020

Minutes - Tuesday, March 24th, 2020

3:00pm – 4:31pm

Meeting participants

Conrad Mearns, Joshua Dempsey, Damon Schafer

Amendments to previous Minutes

None

Agenda Items

- Start document for tracking tasks
- determined location for future wiki
- rescheduled all future meeting locations to Zoom
- start task to determine acquiring Farming Simulator

No Votes

No Motions

No items held over

New business

- Review Farming Simulator Terrain API

Next meeting

- Tue 31, 3:30pm, Zoom

Apr. 8, 2020

Sent another email to Mr. Shrestha to touch base with the condition of the project given all the Covid-19 concerns.

Dear Mr. Shrestha,

I am writing you to discuss potential concerns caused by the recent COVID-19 outbreak. Our main concerns are access to the lab, getting farming simulator, and future meetings.

Due to the current state of the pandemic, our group is unable to meet on campus. Consequently, we will not be able to access the lab to work on the virtual reality elements of the project until the virus is better controlled, and the quarantine is lifted.

Regardless, my group and I are still dedicated to completing this project. For us to complete our project and begin working on solutions, we need access to Farming Simulator 2019. How exactly should we go about this? Are there any keys or disks available now? Since some of us are not near campus and/or do not have disk drives, keys would be more convenient. Or should we begin the formal process of procuring keys for our project? Once we have access to Farming Simulator, we can begin working on the solutions to the problems we discussed.

Additionally, if you wish to meet with us again this semester, we will have to use Zoom—or equivalent software—to videoconference. Do you have any concerns with this solution for future meetings?

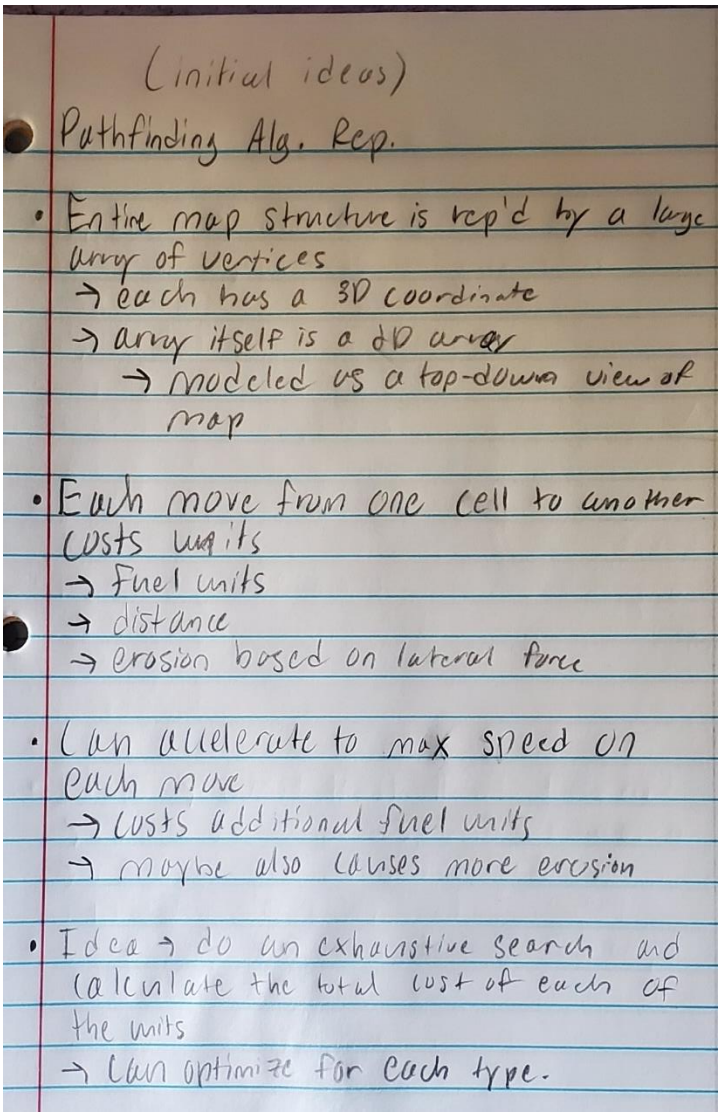
Please let me know your thoughts about our concerns and solutions. I look forward to hearing from you.

Sincerely,

Damon E Schafer

Apr. 12, 2020

Thought about an initial solution to the pathfinding alg.

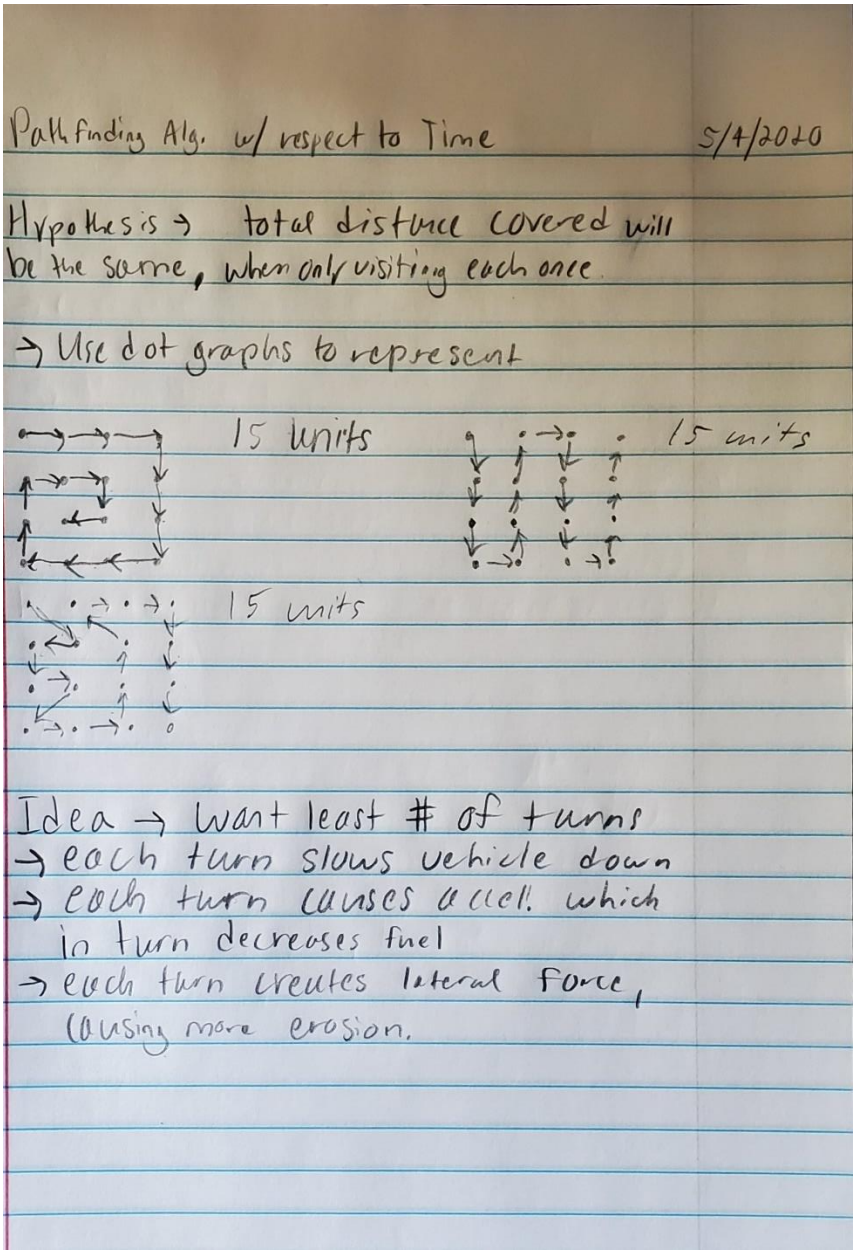


May. 4, 2020

Made some edits and improvements to the logbook. Began looking at the ability to procure farming simulator keys so the team can work on editing the default map. Have not heard back from Mr. Shrestha at this point, so we do not know the exact state of the project. We cannot work in the lab; however, we should be able to work from home once copies of the software are obtained.

Talked to the team members about the status of the project, and where everyone is.

Did some basic pathfinding algorithm research.



Sept. 1, 2020

Conversed with Dev on how to get the VR gear so we can work with it outside of the lab.

Sept. 2, 2020

Began researching on importing GIS elevation data into farming simulator. Took a better look at the repository, and some questions were raised.

1. Where is the scripting mentioned in the modDesc.xml file?

2. Why does the map always crash when I attempt to open it in the GIANTS editor.

Sept. 3, 2020

Sent the following email to Dev. We were unable to find some of the files referenced within the GitHub repo. Dev later replied and said he would upload all the files he has to the cloud.

Dear Mr. Shrestha,

As my team and I begin working on our project for this semester, I had a few questions about files from previous semesters. The current repository that we have access to, located here, appears to not contain all the files from the project. Do you have any other files that would be useful to us? We are specifically interested in a scripting folder, and a file called mission00.lua. Also, as we look into getting Farming Simulator running, we may have to purchase another copy of Farming Simulator 2019. Do you have any other copies or access to the game other than the copy given to us with the VR gear?

Thanks,

Damon E Schafer

Sept. 4, 2020

Received Folder access from Dev for all the other files associated with the last Capstone Team.

Began some research on how to get real world elevation data into Farming Simulator. There are a couple of videos and procedures out there on how to do this. I looked at the following two videos.

1. Farming Simulator 19 - Modding Tutorial - Real World Terrain
2. Creating map Dem from Google earth

I spent some more time on the first video initially. I also tried to follow the procedure, and I was unable to find the required file type and GIS data for the

Cooke Farm location online through the USGS The National Map. I was therefore unable to continue with the initial procedure.

There are some files located in the GitHub repo that resemble elevation data. However, since there is not any documentation about these, I am not sure if they are for the Cooke farm. I have chosen to not use this data.

Acquired a copy of farming simulator for the group. Conrad Mearns acquired a copy of Farming Simulator 2019 through Steam. We created a group account that we can all access offline. Credentials are as follows:

CyberFarmerDev

SJ9thZA8XgQHXAf555

Account Name

cyberfarmerdev

Total

$26.49

Confirmation code

2610354436656904135

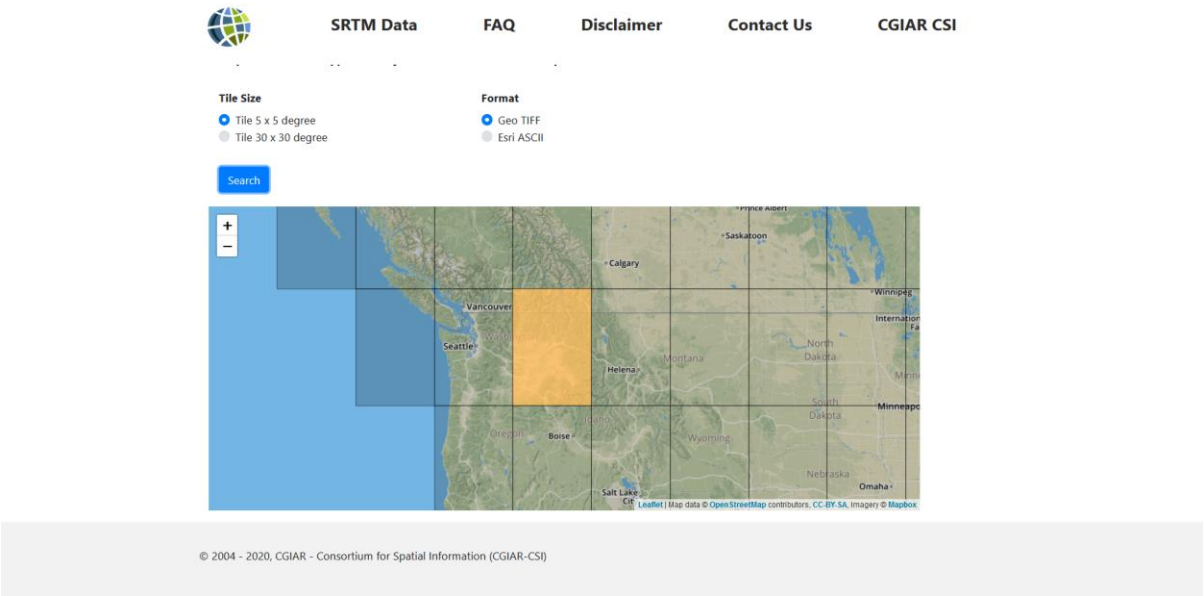
Sept. 8-16, 2020

I installed the copy of Farming Simulator that we purchased.

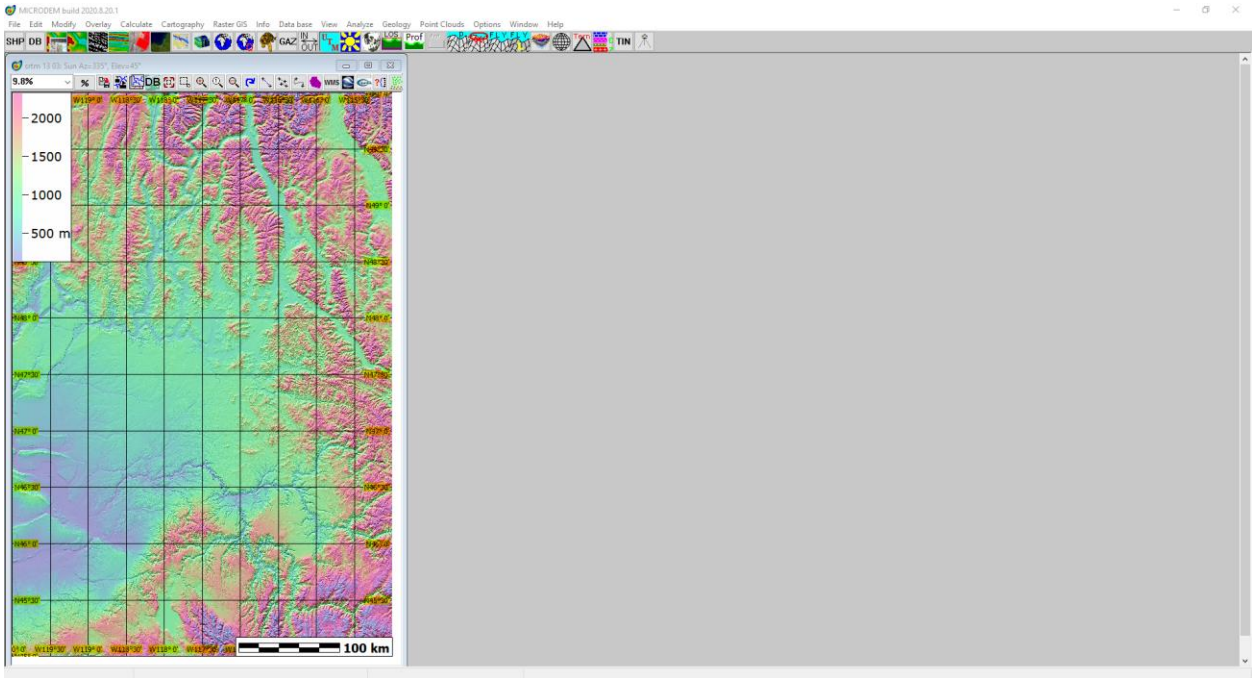
After failing with the first video, I began to follow the procedure within the second video. I revised the steps and listed them below. This is the same procedure I followed to get real world GIS data into Farming Simulator.

1. We need GIS data for the Cook Farm location. This can be downloaded from a variety of sites. We are using srtm.csi.cgair.org for this procedure. Navigate to the link below and select the data for your desired region. Verify that the 5 by 5 degree and geoTIFF format is selected. Get the Actual data from

http://srtm.csi.cgiar.org/srtmdata/.



2. Installed Microdem. This software is required to extract the information from the files that were just downloaded. https://www.usna.edu/Users/oceano/pguth/md_help/html/download_md.htm
3. Open Microdem, and navigate to Open->Open DEM/Grid
4. From here, select the downloaded .tiff file from earlier. At this point, it will be opened and shown in Microdem. It should look as the image below.



5. For the next step, the actual GPS coordinates of the desired location are needed. The coordinates that roughly correspond to the eastern Cook Farm are 46.781558, -117.080088.
6. Go back to Microdem with the opened file and navigate to the coordinates in the map view. The status bar shows the current coordinates at the mouse cursor. Use the Zoom tool as many times as needed. For this procedure, I zoomed in three times, each by a factor of two, and would suggest 6-8X magnification.
7. Then select the Subset and Zoom tool, which corresponds to the logo below. Drag a rectangle over the region you want to create a map for.

8. Then right-click and select “Display Parameter,” then “Elevation.”
9. Leave all settings as is and press the “z Range” button.
10. The next steps (10-12) are optional. Follow these to verify that your selected map region is the actual area you want to replicate. First, verify that Google Earth is downloaded and accessible. This is done with Google Earth Pro on a Windows Desktop which can be downloaded here.
11. Then select the icon below to export the current map to Google Earth. If Google Earth is opened, it will automatically zoom to the map location. It should look as shown below. 

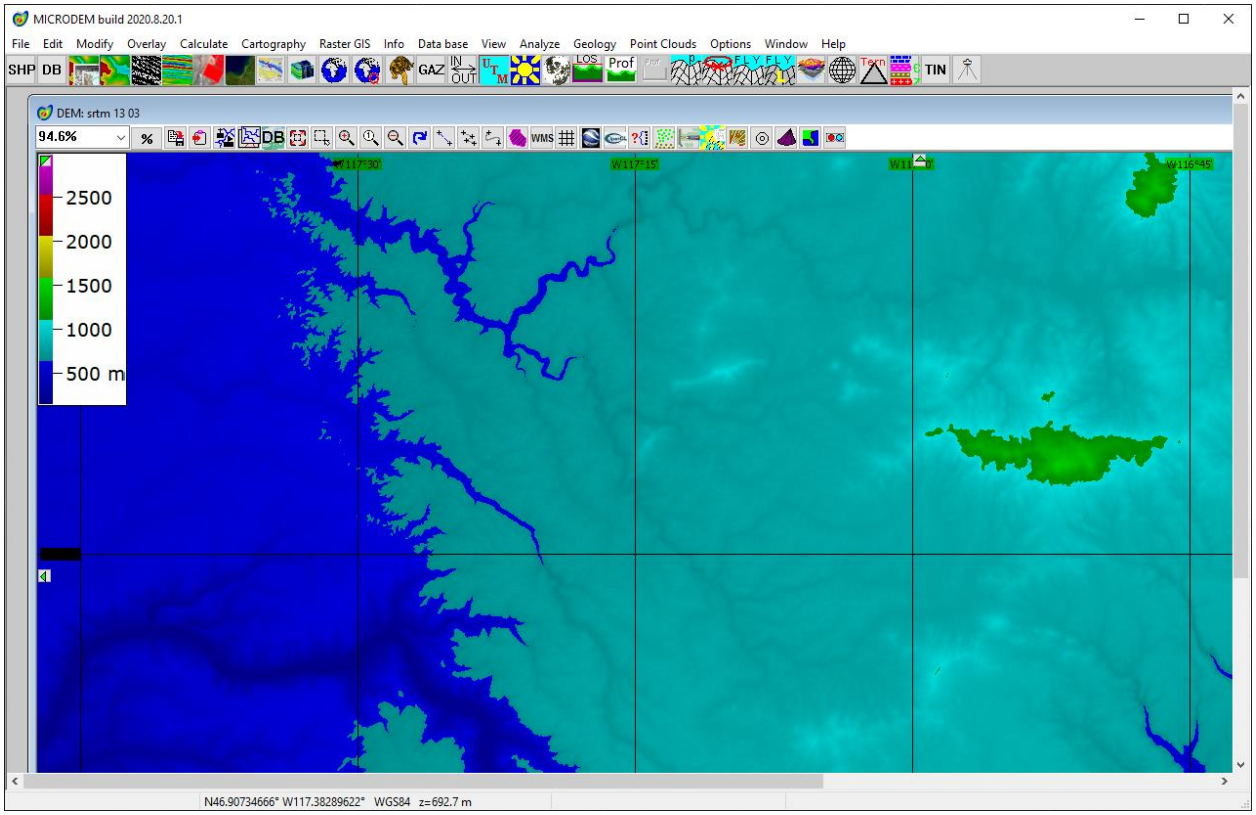


Figure 1. The DEM file of the desired location open in MicroDEM.

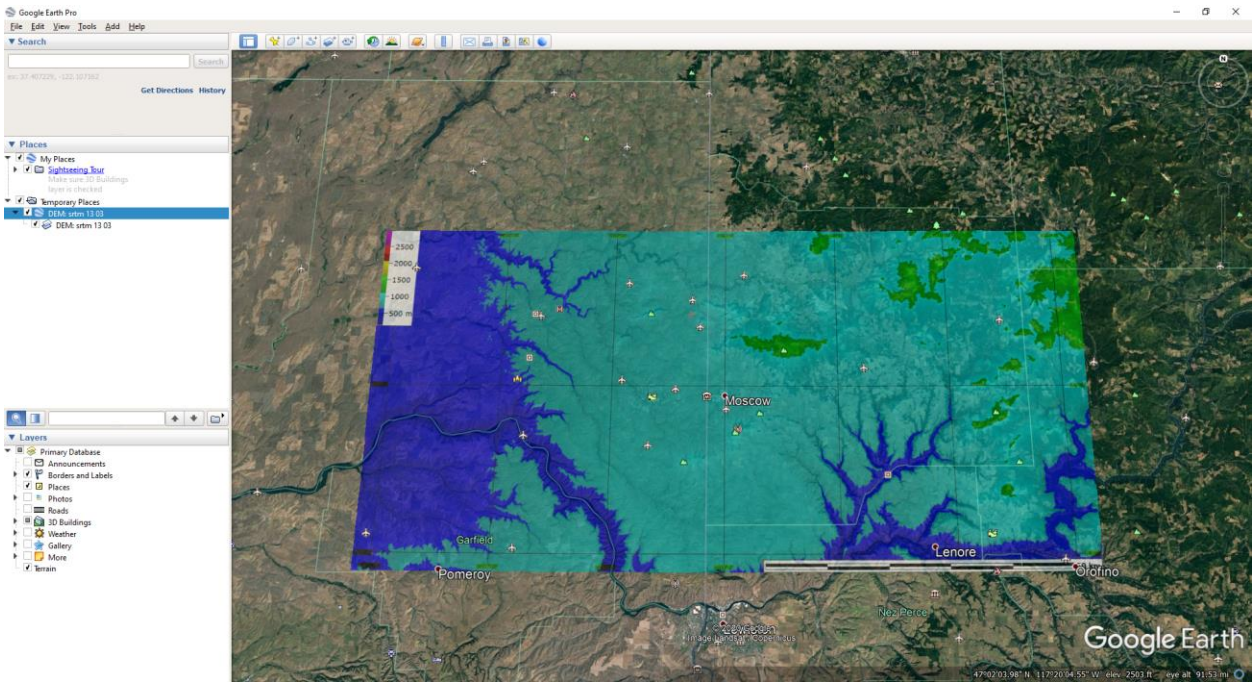
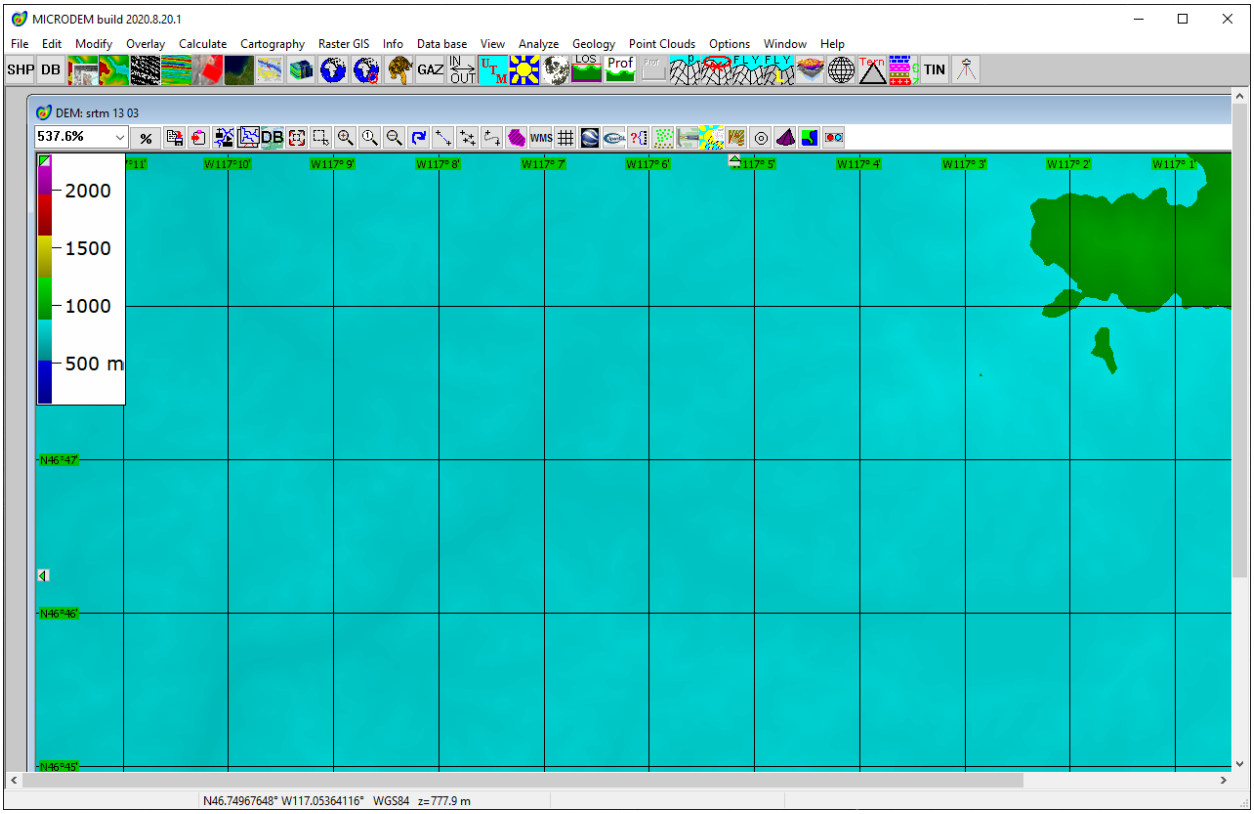
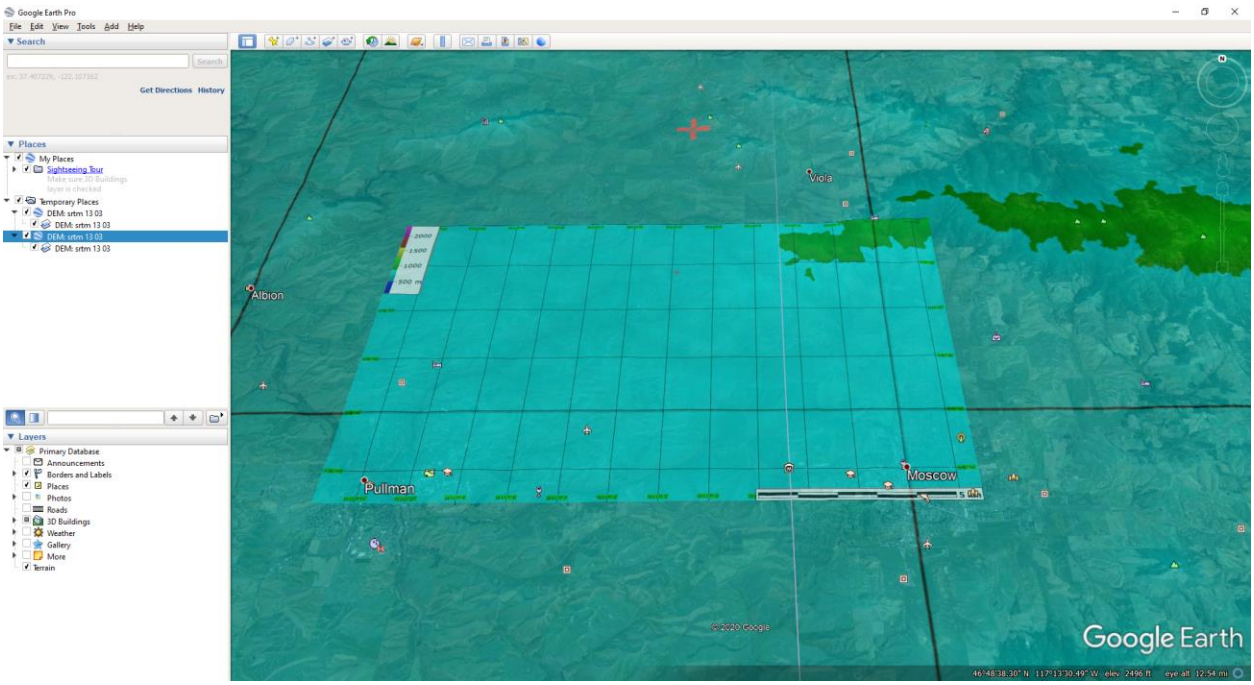


Figure 2. The exported DEM file into Google Earth.

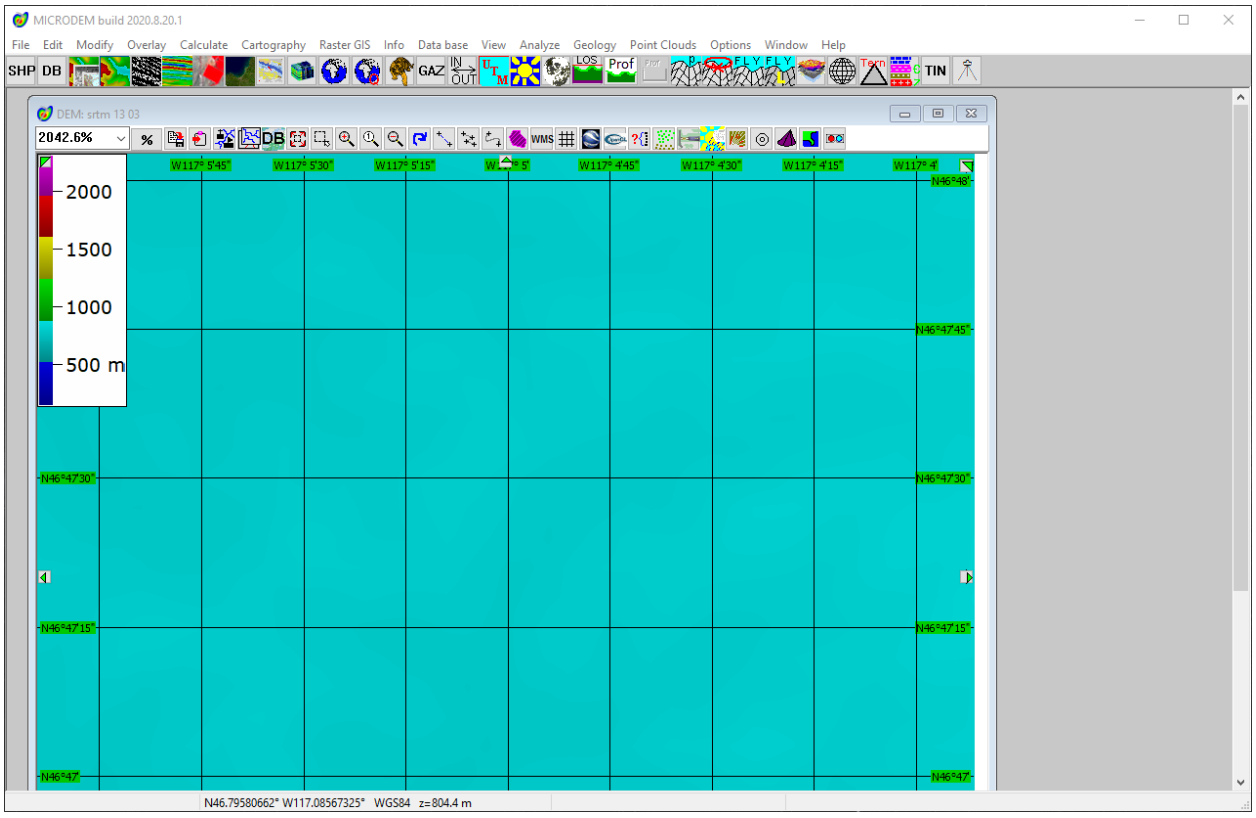
12. Verify that the region shown in the file is the area you want to make the map for. Or repeat steps 6-12 with a higher zoom setting.
    - It is worth noting that when I did this, my first time was for a region far too large.
    - repeated the steps with a much higher zoom, about 537%. See image below.



    - I also exported this to Google Earth to verify this was a better map selection. It looked as follows.

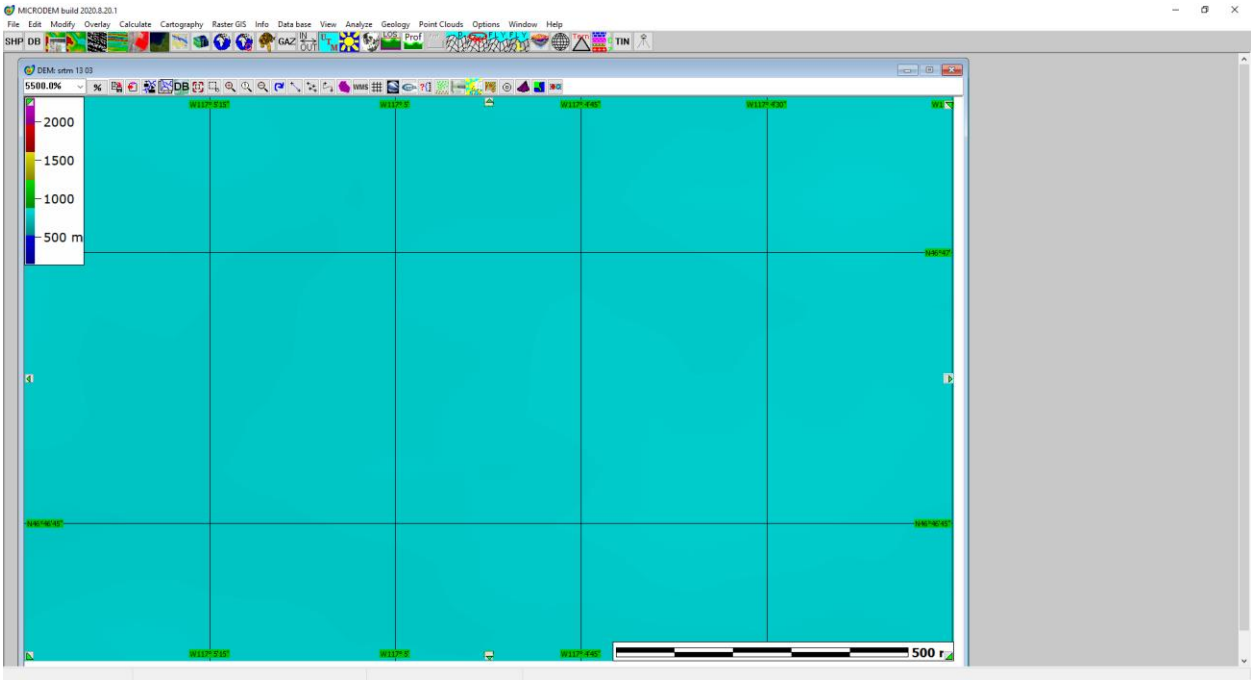


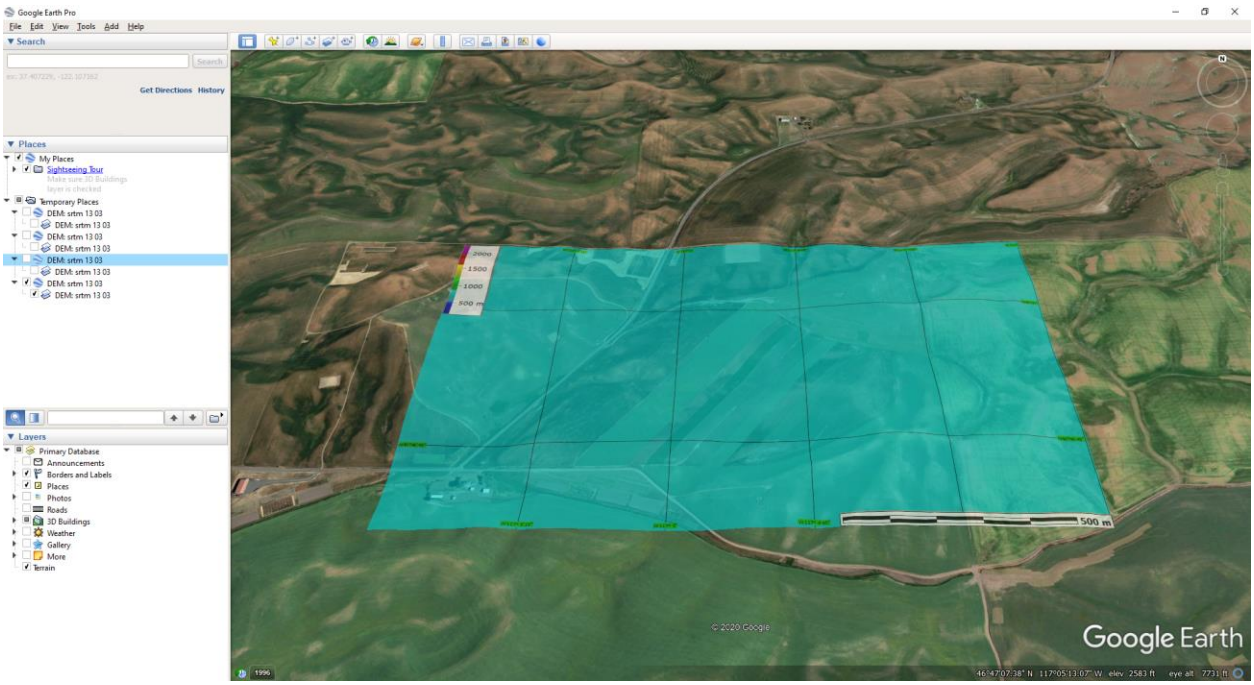
- This still was not good enough of a selection. It captured the entire distance between Pullman and Moscow. Since we do not want this large of a map, I repeated the steps again.
- The result was a magnification of 2000%, and it looked as shown below.



- I then exported this to Google Earth as before. The result was better, and the Cook farm was within its selection. It still captured too much of the other space, so I did it one more time.

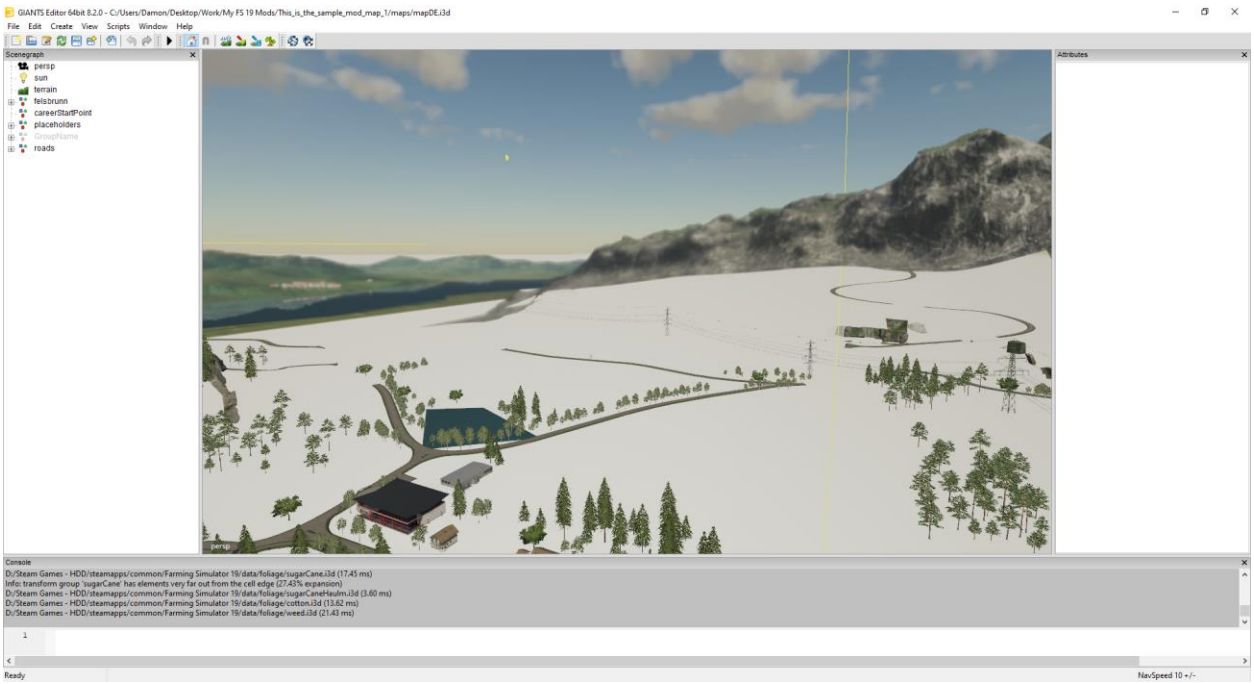
- The following image were the last result.





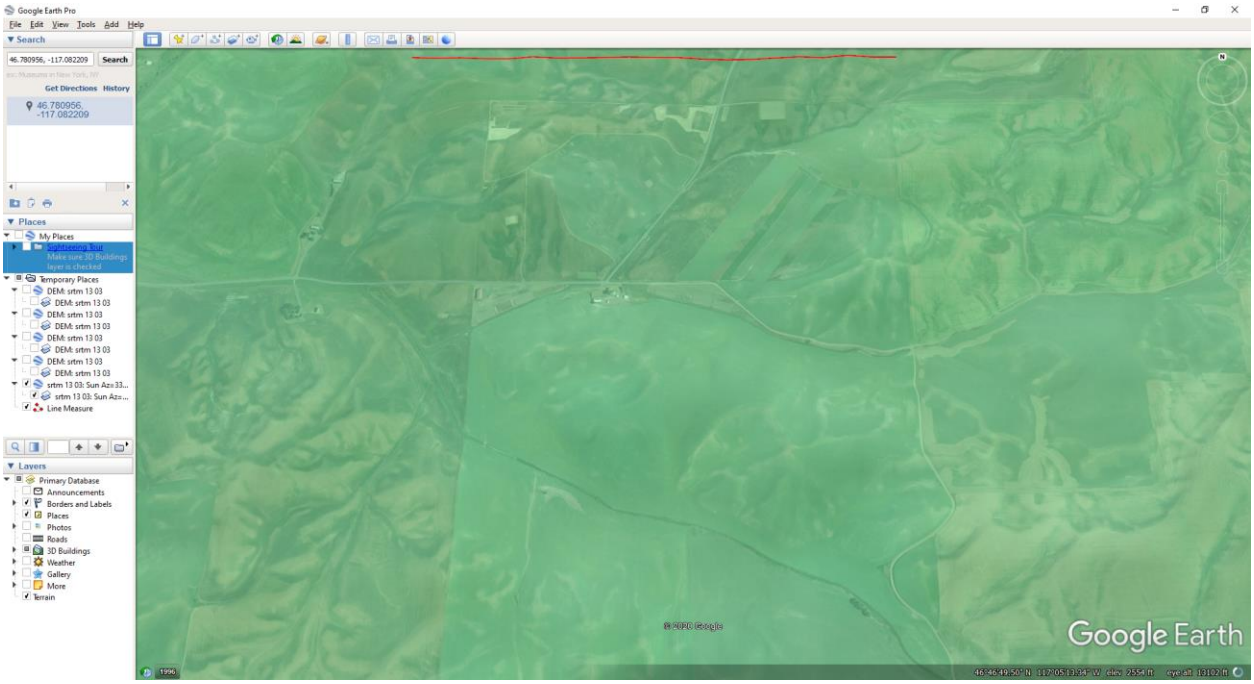
- As the image shows, this last selection was perfect. It captures everything that is desired.
- At this point, I continued with the procedure to test how the result would appear in the GIANTS editor.
- This included taking a screenshot of the layer in Google Earth and resizing this.
- I then opened up GIANTS editor, and created a new mod using the “Create new map mod from game.”
- This then set up a beginning map with terrain, buildings, and detail. This turned out to not be very helpful.

- I transferred the dem file to the map mod to see how it turned out, and it appeared as in the image below.

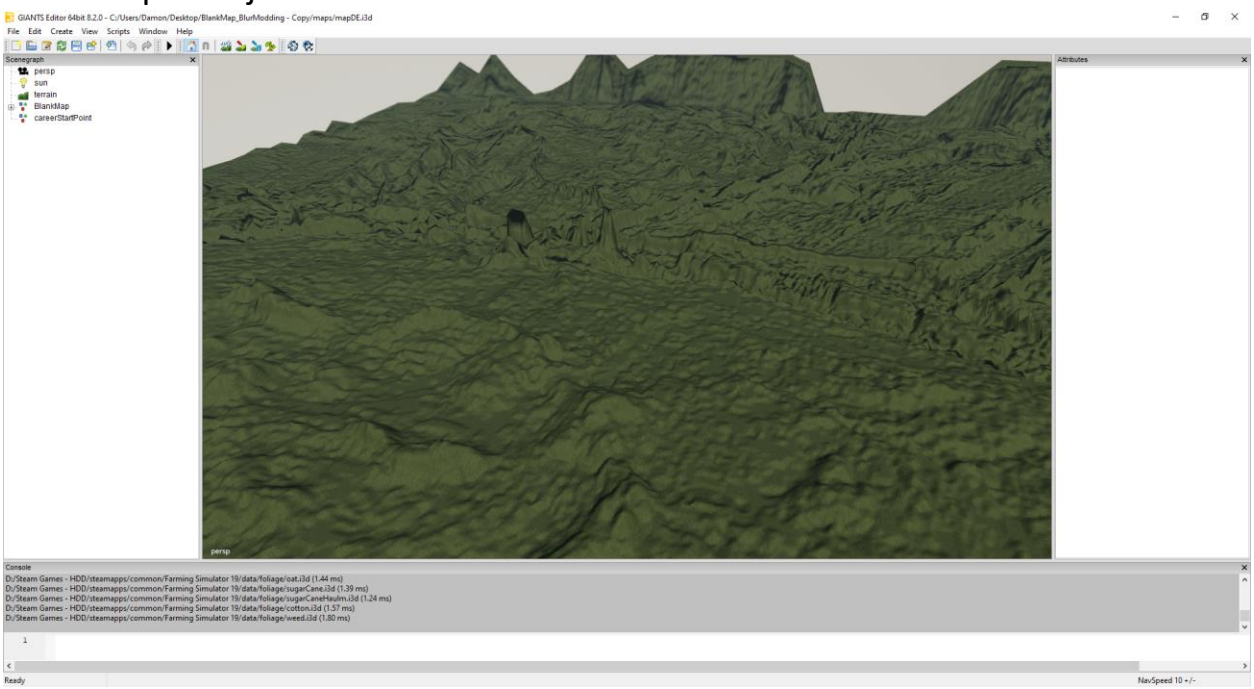


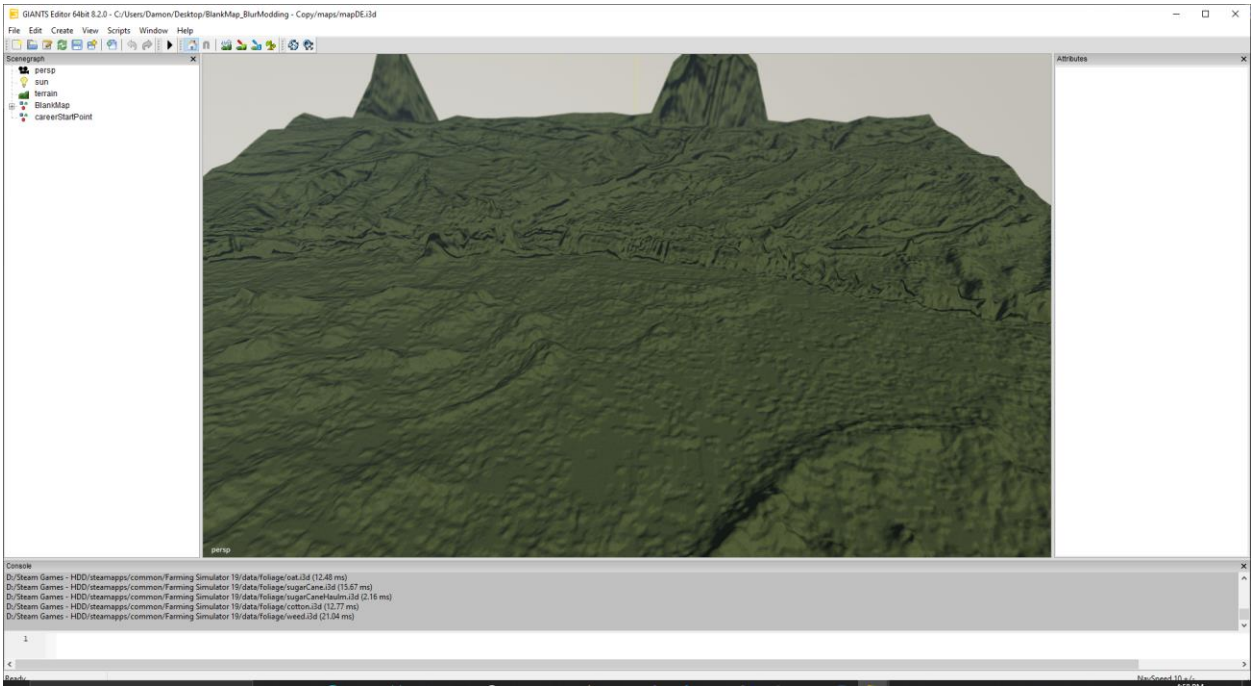
- This is not a correct result, but I figured this was because of the existing map. So, I downloaded a blank map file from https://ls-portal.eu/blank-map/.
- I then retried the procedure. First, I zoomed out quite a bit in MicroDEM, and exported directly to Google Earth. Note that I failed to follow steps #8,

9. I took a screenshot of Google Earth, which is as follows.

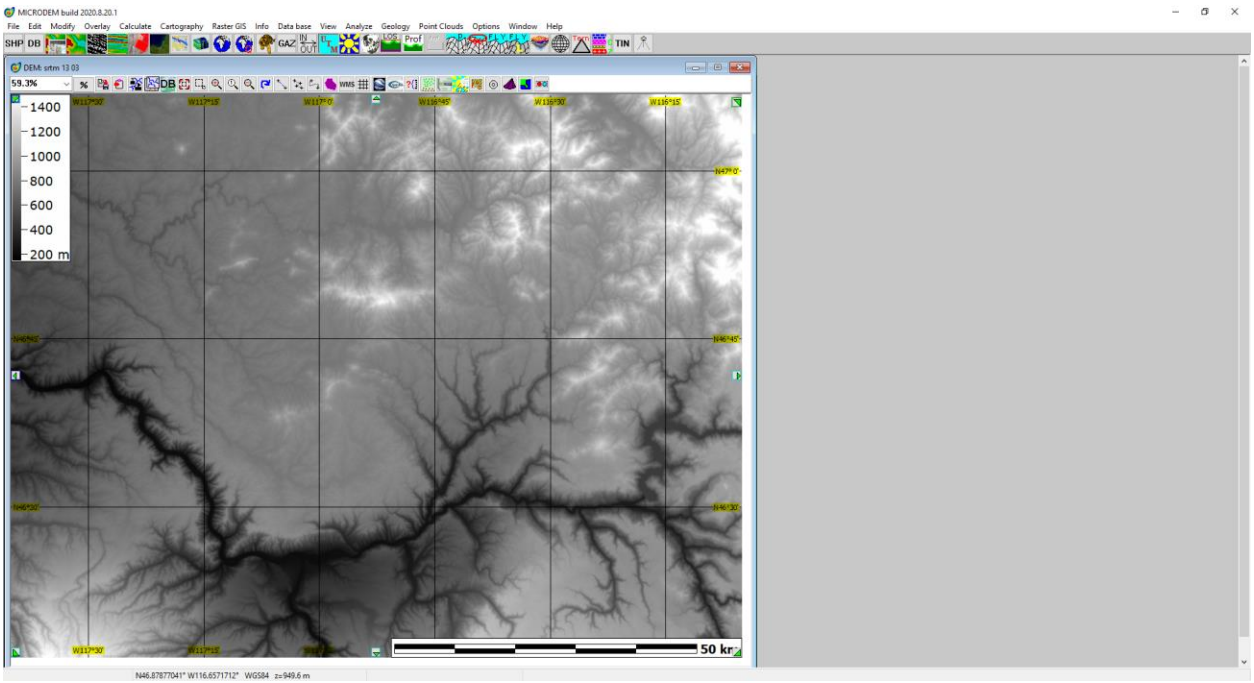


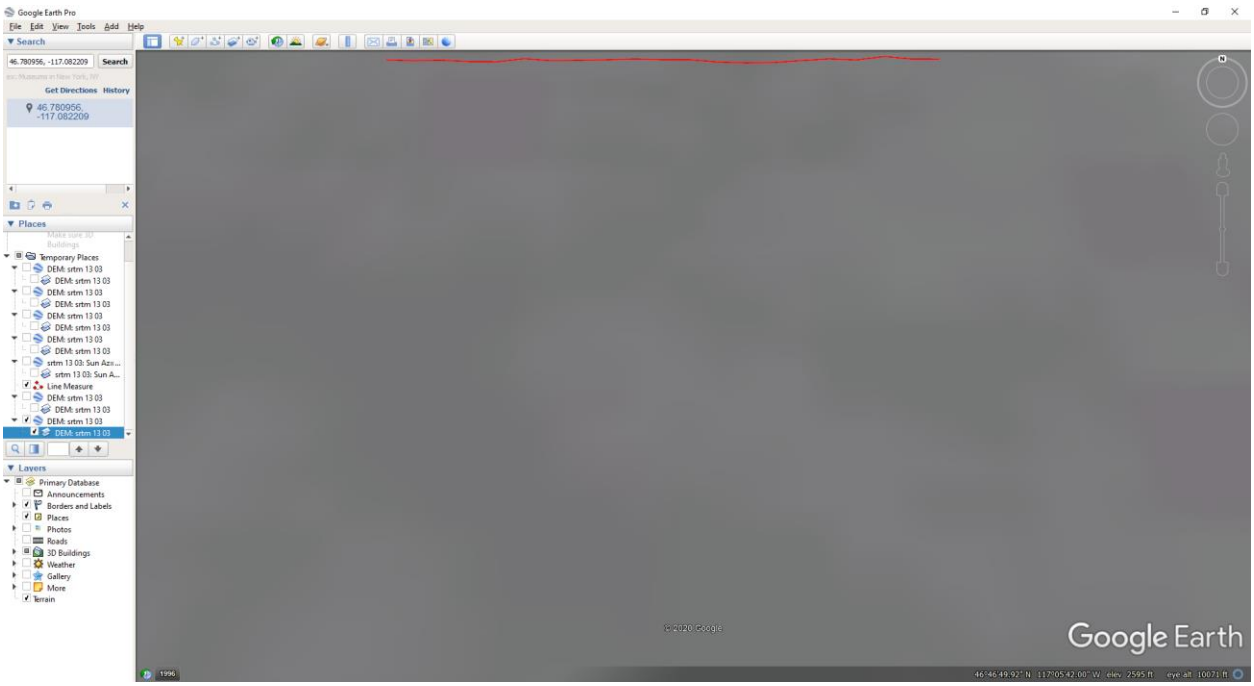
- Note that there is now a red line at the top. This is used to help scale the map, and it is explained in the steps below.
- I then cropped a 2km region of space from this image, and placed it in the blank map mod just created. The result is shown below.



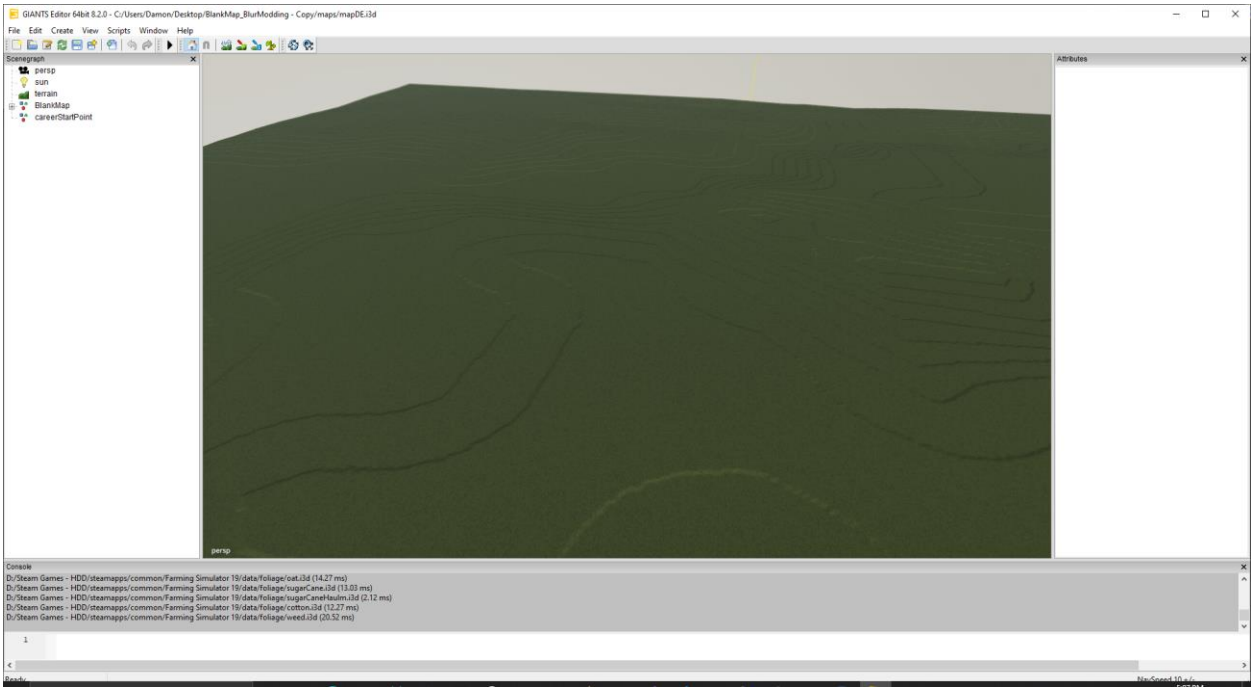
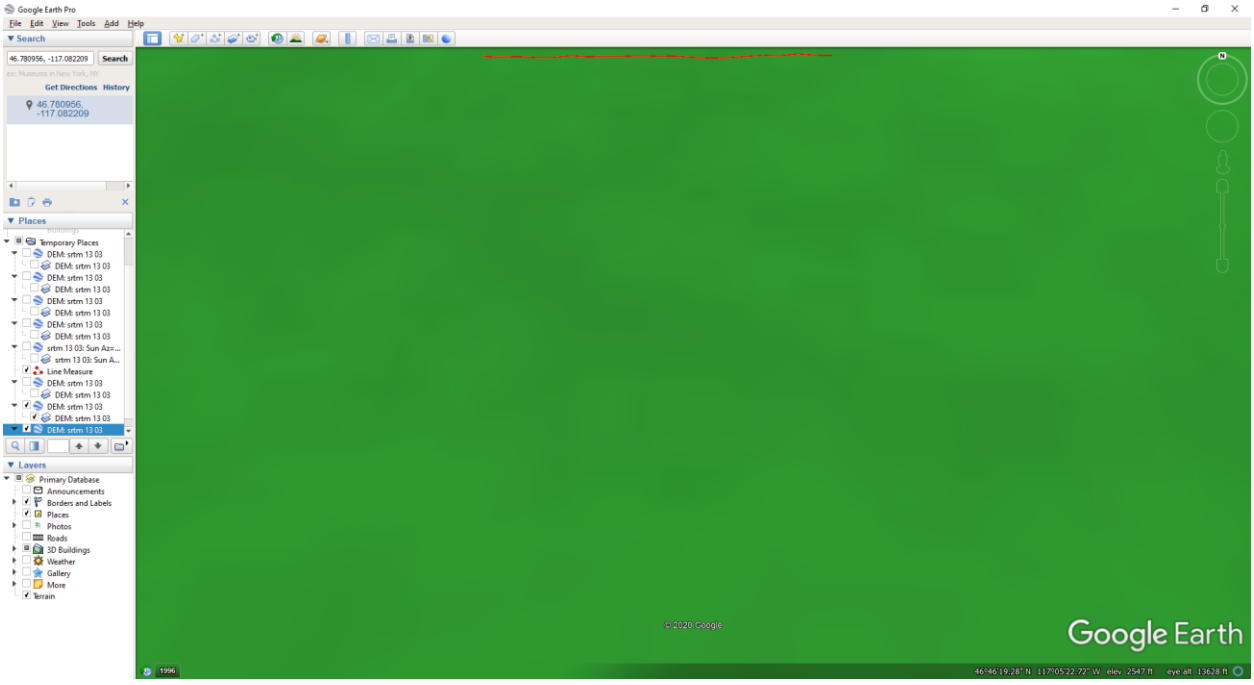
- This result is also not usable. There is quite a bit of noise in the map, and it does not resemble a real-world landscape. This is better than the first attempt, however.
- The issues in the map are most likely caused by skipping steps 8 and 9. I repeated what I just did with those steps included. The result is as shown below.
- 

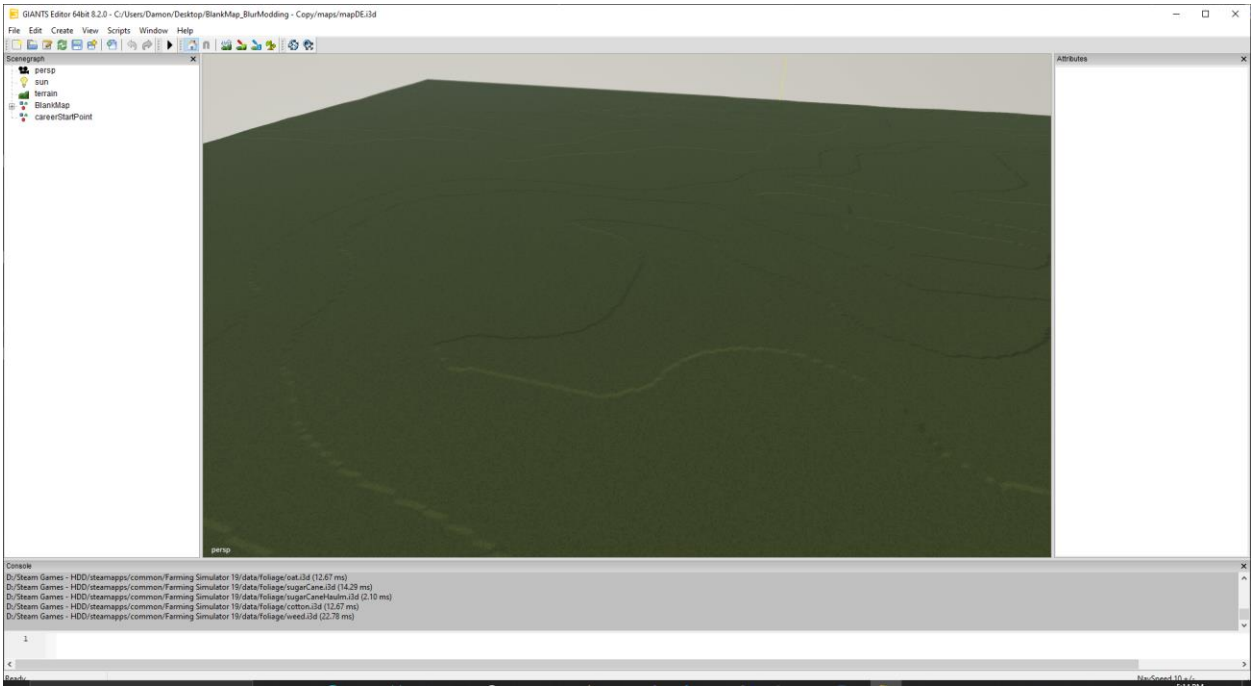
- This was better, but still not optimal. I figured I would try the same, but with a changed zRange in the Elevation data. I set this to 1500, since the range at the left showed the region I was interested in to be around 1000m. I did not want to lose the data, so I cut off anything above 1500m. I also changed the DEM to monochrome. The result in MicroDEM looked as follows.

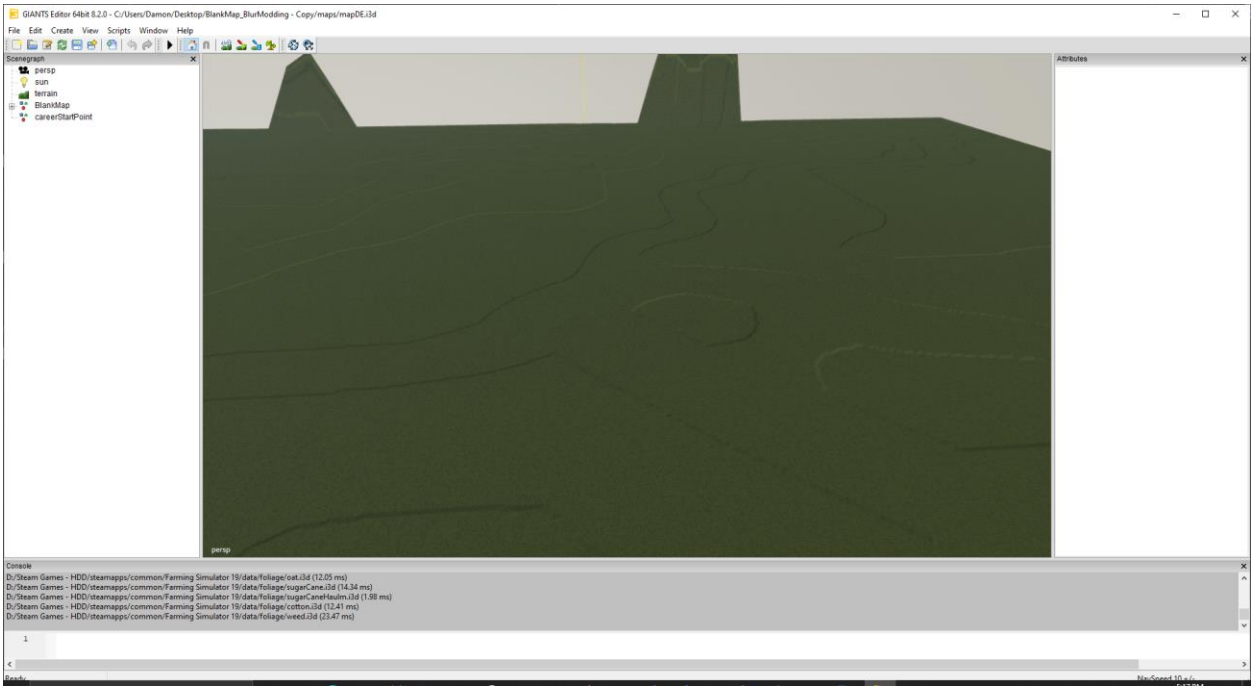
- 

- I then exported to Google Earth and followed the procedure as I did before. I also tried setting the opacity of the layer in Google Earth to 100% to see what this resulted in.
- 

- The result in the GIANTS editor is below.

- 
- This is the best solution so far, but there is low resolution here. With some work, it could represent the farm. However, I wanted to try again with some changes in the procedure.
- I retired with a zRange of 0-2000, with color. I then exported to Google Earth. Also, another issue I might be experiencing here is that the resolution of this data is just too low. The SRTM site specified it as 30m resolution. This could be the cause of the flat spots in the map.
- 

- The result in GIANTS editor is shown below.
- 

- This was similar to the last result. The changes I made here appeared to not do much. I retried once again and got the following result.
- 

- Excluding the artifacts which appear as mountains in the map, this was still very similar to the previous result. This implies that the resolution of the data is not small enough to create this map effectively. So, I searched for

other sources of DEM data online. Regardless, this procedure ends here, and I will create another procedure below.

Sept. 16, 2020

I began research on other sources of DEM data. Ideally, I want better than 30-meter resolution. I contacted our sponsor Dev to see if he had any data. He sent me an excel file with 2-meter resolution data points. If I can find a way to create a DEM file from this, I can get it into Farming Simulator.

Sept. 17, 2020

I researched for some sources of DEM images with higher resolution, and I visited the following site https://yceo.yale.edu/major-dem-sources. From here, it showed that the most significant source of DEM data for the continental United States is The National Elevation Dataset which is accessible by the National Map Viewer. This is supported in 30meter, 10meter, and 3meter resolution.

At this point, there are two ways to progress with the map.

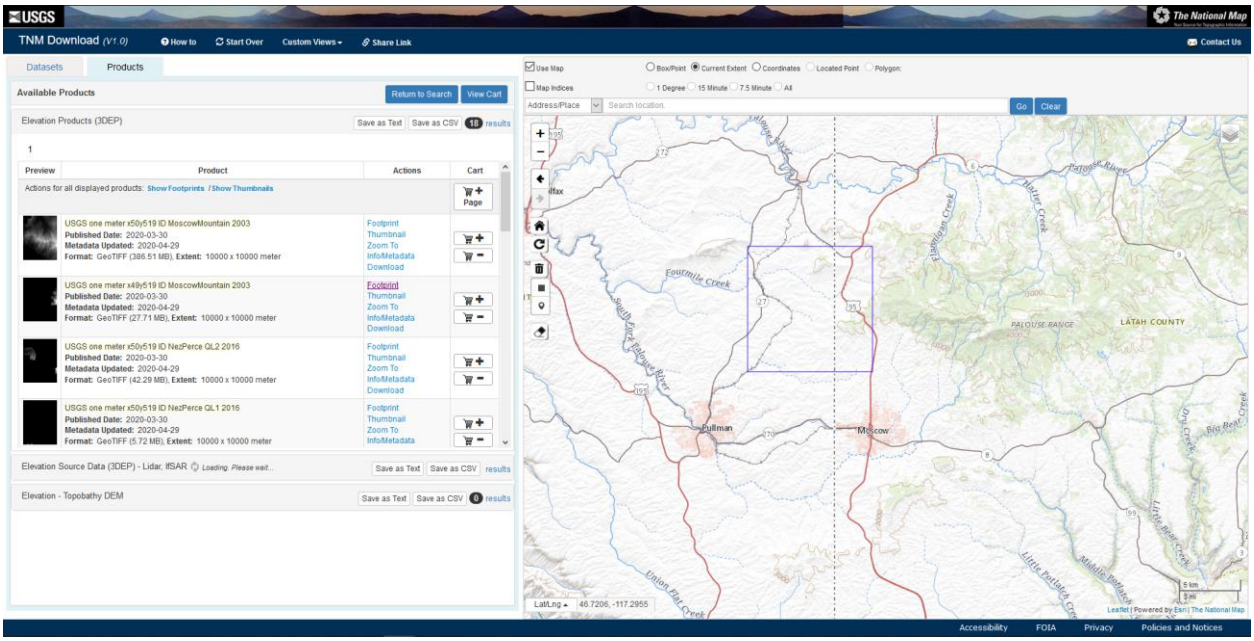
1. Use the 2m elevation data given to me from our sponsor and translate this to a DEM file using some GIS tools such as QGIS.
   - This will take some more time to learn how to use the GIS software.
   - There are some procedures and descriptions on how to do this.
   - Will be the most accurate data we can acquire.
2. Use the 3m elevation data from the National Elevation Dataset.
   - This is already in DEM format, so no GIS software other than MicroDEM and what we have already been doing is needed.
   - 3m is not much less in resolution than 2m.
   - Data may or may not be available however.

The plan is to attempt option #2 first. If there is not data available, or if the resulting map is not accurate enough, then I will attempt option #1. Even if the first map turns out perfect, however, I will still attempt option #1 to learn more about using GIS software.

For option #2, I did the following steps.

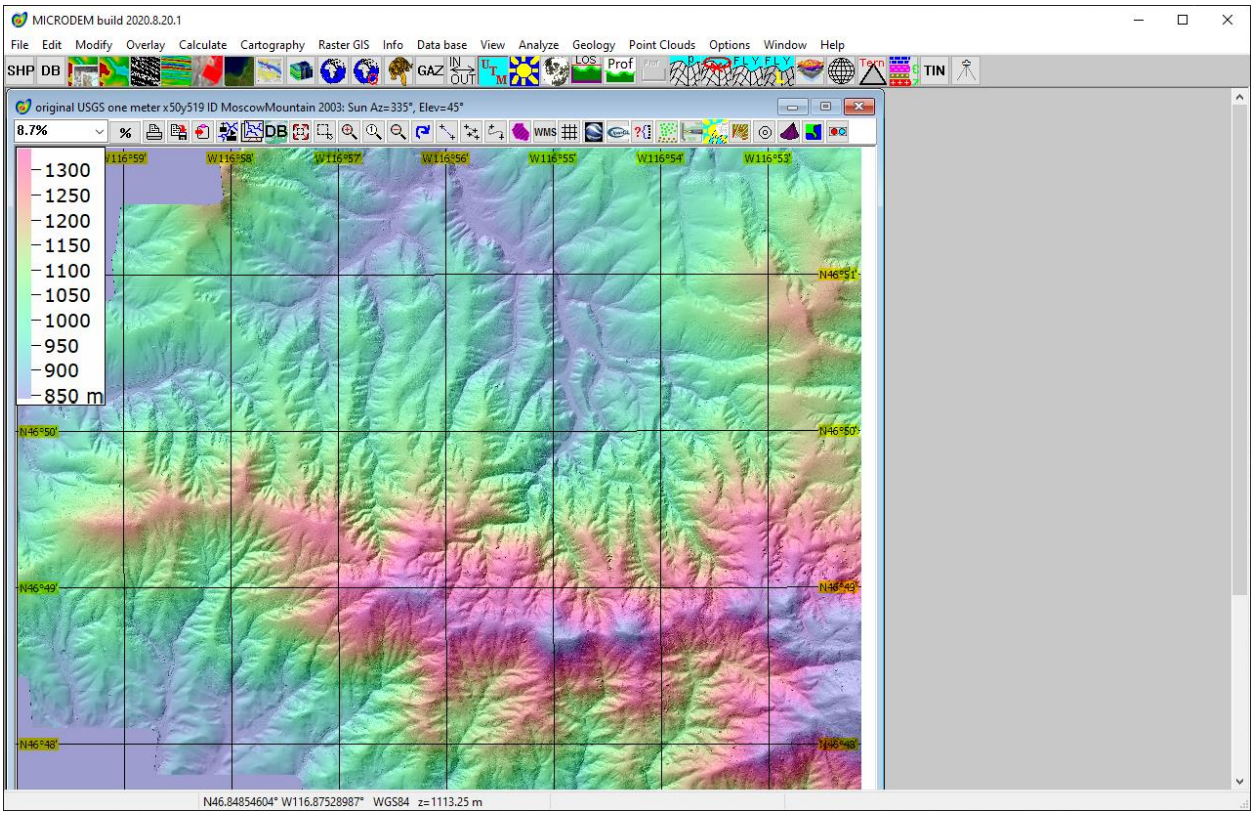
1. Visited The National Map at https://viewer.nationalmap.gov/advanced-viewer/, and clicked on Data Download.

2. I then went to the coordinates for the Cook Farm. Then, in the Datasets tab to the left, I selected all Elevation Source data, and all Elevation Products. Remember that we want to specifically see DEM images, but I also wanted to see what other data was available. I found the following data as available for download.



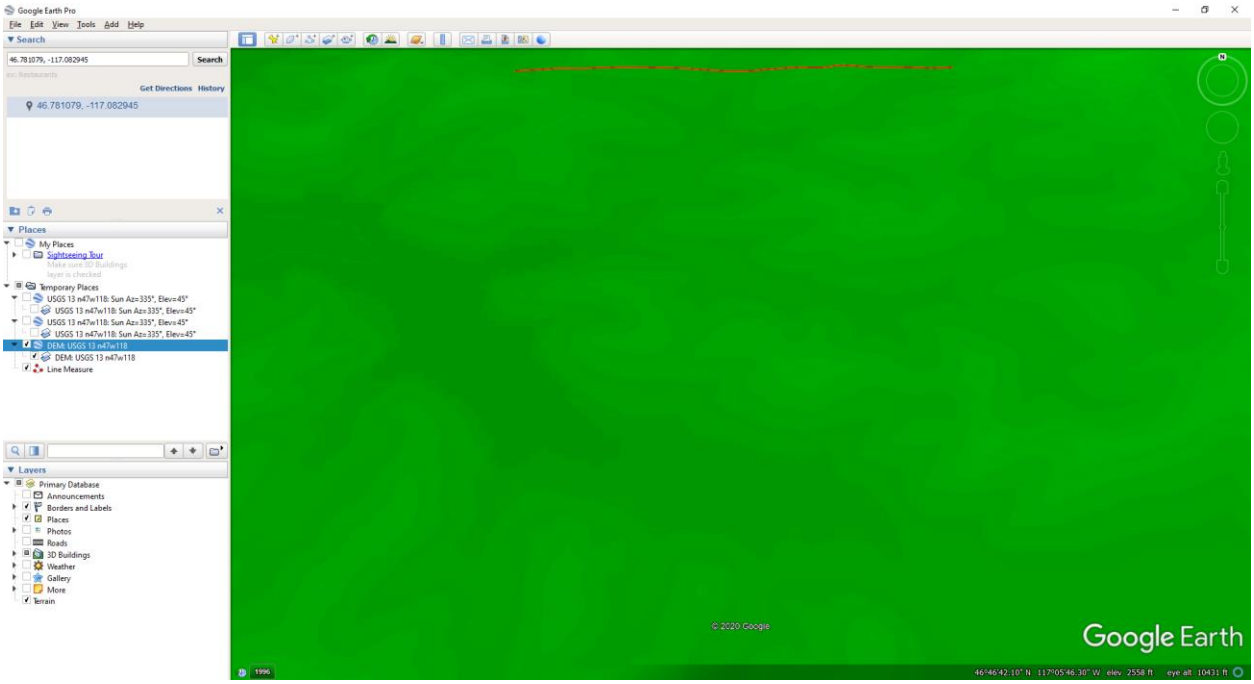
3. In the image, the box in the map shows the extents of the data. Luckily, there is a dataset that includes the Cook farm. And better yet, it is 1meter resolution. It is in GeoTIFF format. I downloaded the first item in the list.
4. Now, using what I learned from the last week, I opened MicroDEM and opened this file in the application.
5. An error dialog opened, and I realized that I need to download some additional tools to open this file.
    a. I downloaded ODGeo4W tools through a 64-bit network installer located at https://trac.osgeo.org/osgeo4w/.
    b. I installed all of the available components. The one that is specifically asked for in the dialog was GDAL.
6. With the newly downloaded files, I attempted to open the file with MicroDEM again. With the newly downloaded files, the DEM was opened

successfully, and it looked as follows.

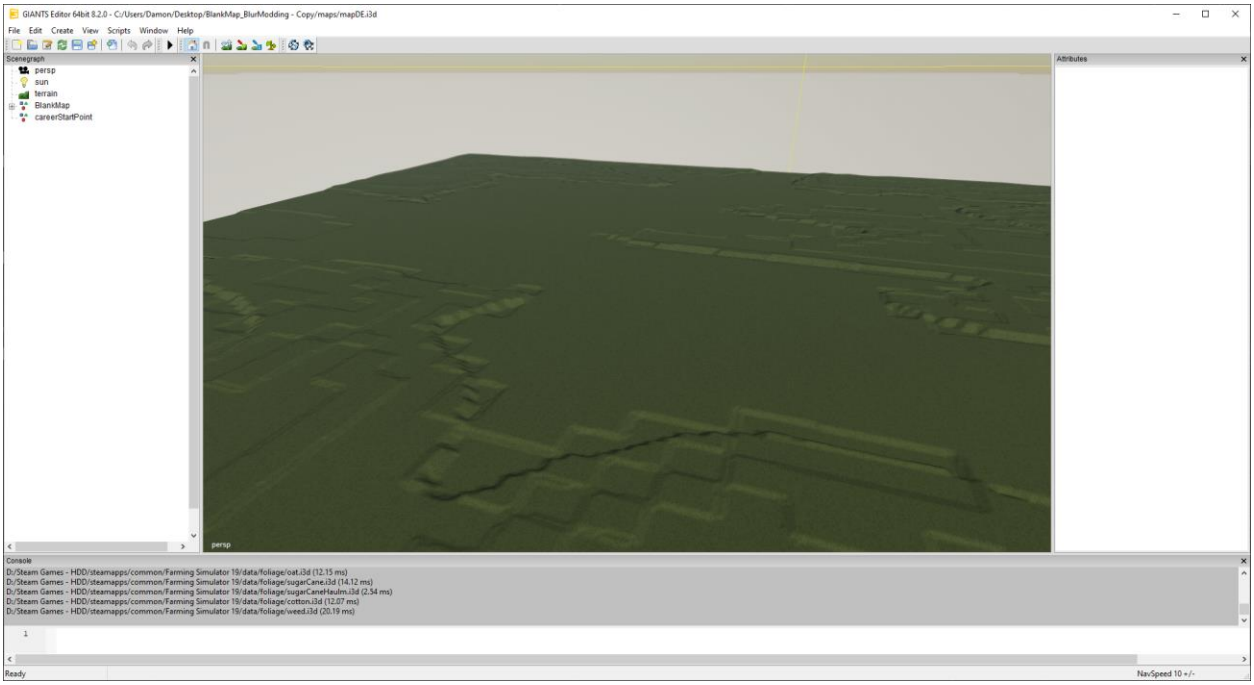


7. This was not for the correct location, however. So I searched for more data sets and found a 1/3 arc-second data set including the Cook Farm. This translates to 10m resolution, which is an improvement over the original data.
8. I downloaded this data and opened it in MicroDEM. I then zoomed closer to the coordinates following the procedure described earlier. I displayed the elevation parameter and exported it to Google Earth. In Google Earth, the

new data looked as follows.



9. I then created the 2km map and put it into the map mod we made earlier, and the result was not useful. The map generated from the DEM image was just blank, and had no elevation associated with it. I retried with some different parameters. The result is shown below



10. This was a slightly better result, but the resolution resulted in artifacts in the image. I tried one more time with this dataset. Since this data did not

result in any significant changes, I decided to research how to go forward with option #1.

The first problem to be solved is to create/import the excel sheet into some sort of GIS data. After doing some basic research, I discovered that QGIS would be a good starting program for doing this. It is free, and downloadable at https://www.qgis.org/en/site/.

From here, I attempted to open our Excel datasheet in QGIS. I transferred the 2m elevation data from the spreadsheet to its own, blank spreadsheet.

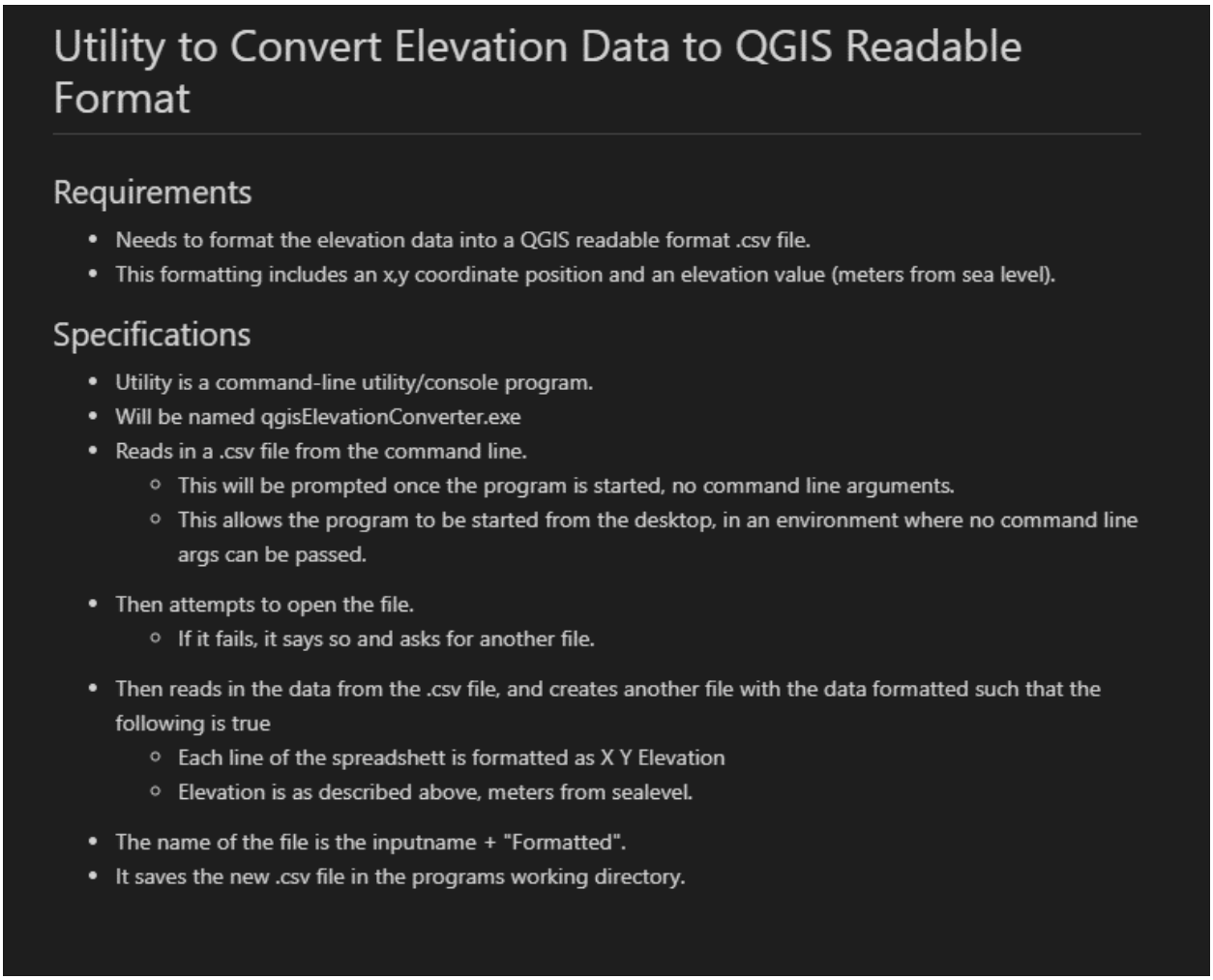
After looking at a couple resources online, the data format given to me will not work without some work. I need to translate it into its own coordinate system. The plan is to create a utility program that reads in the .csv formatted spreadsheet, then creates a new spreadsheet with the correct X, Y position in our own coordinate space, with elevation data for each point. At this point in time, I am ignoring the WGS84 projection, which is an ellipsoid projection. I will be assuming no projection. Since we are dealing with a small region of space, I figured I will try this step first. It is simpler to implement, and if I run into issues and need to find another procedure, I will have less time invested.

https://gis.stackexchange.com/questions/78497/qgis-making-a-topo-map-from-an-excel-file

The first step of this option is to create a correctly formatted excel file that we can work with. To do this, I plan on creating a C++ utility that opens a .csv file and outputs a correctly formatted .csv. This will work for our data sheets.

Sept. 19, 2020

I drafted some requirements and specifications for this utility, and I included them below.

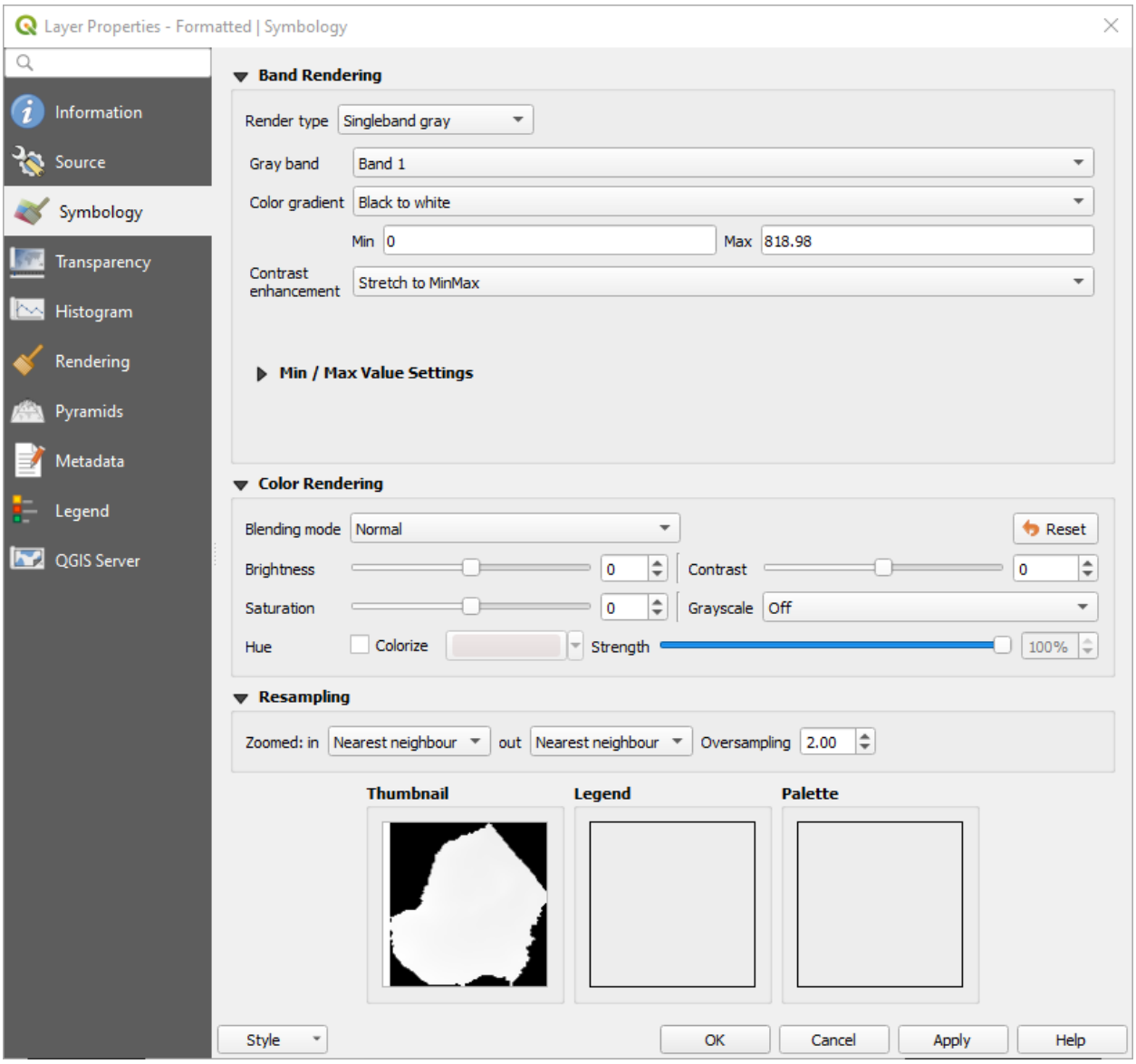


With these in mind, I developed and written the basic algorithm for the program. The format of the file is just the elevation for each point at each location in the dataset. Locations without any elevation data are marked as -9999. Since we know the resolution, we can calculate the X,Y position for each data point. That is precisely what the algorithm did. It read in the data and took the elevation data for each point. With the data, it formatted a new .csv file such that the first column in the x coordinate, and the second column is the y position of the data point, and the third column is that point's elevation in meters from sea level. Each data point has its own row in the spreadsheet.

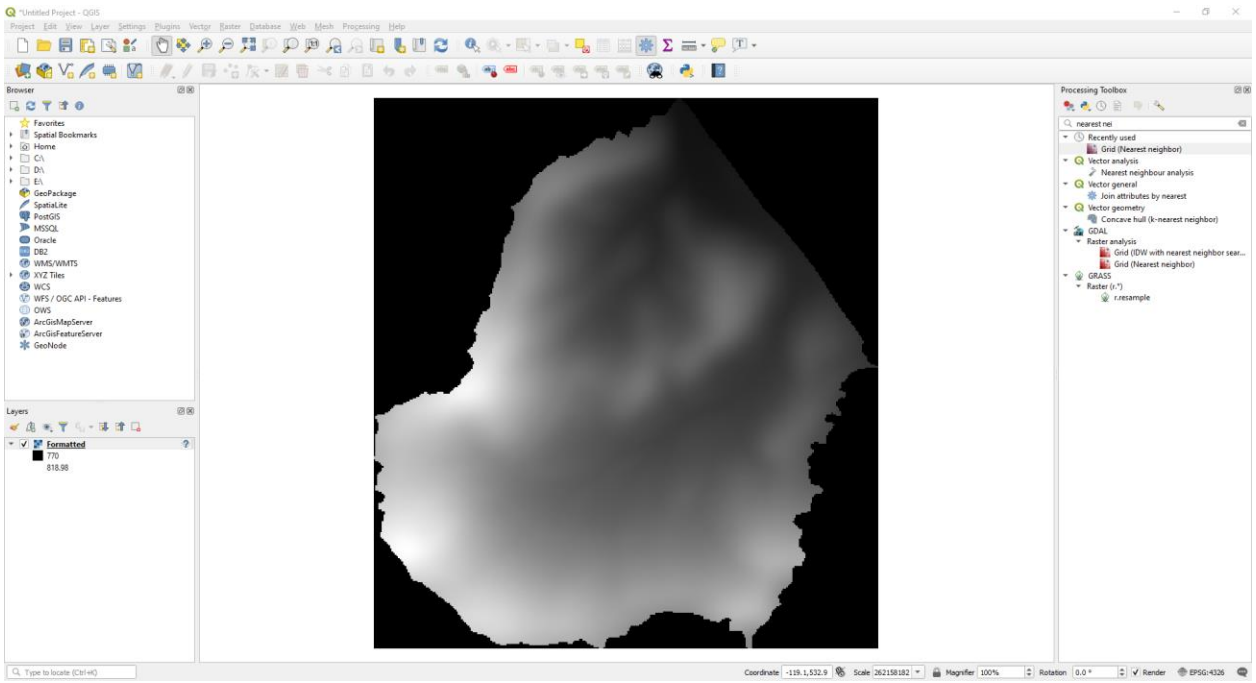
The utility is here https://github.com/deschafer/ElevationConverter.

Sept. 21, 2020

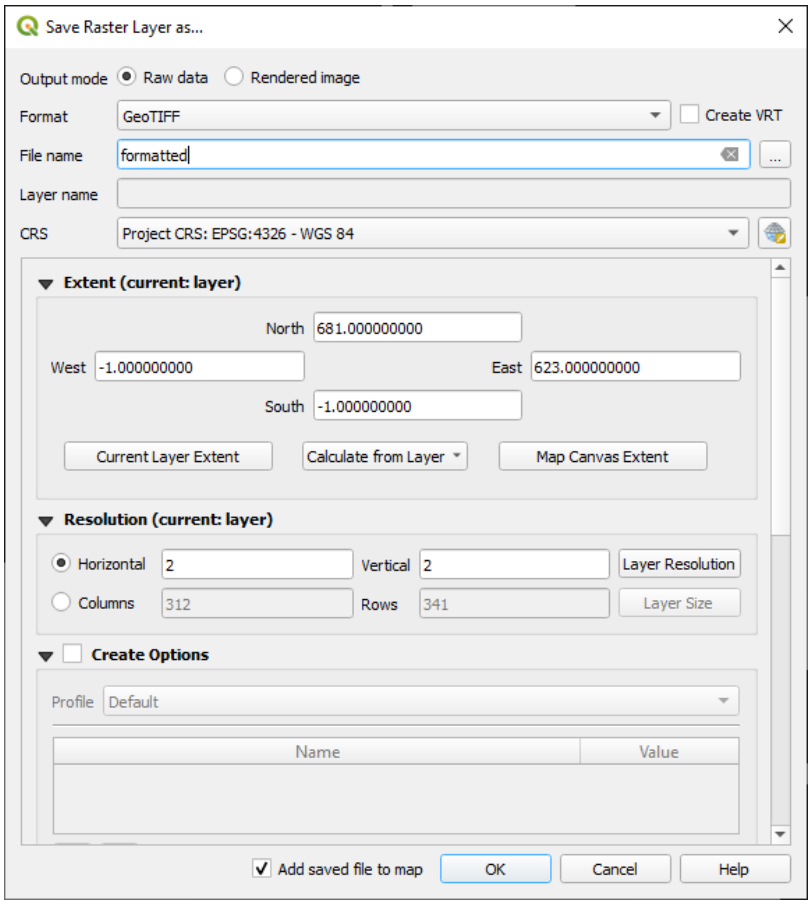
With the new formatted data, I opened this data in QGIS. I followed the procedure marked below.

1. Drag the formatted .csv file into QGIS. Since the data is now formatted in a readable format, the .csv file is automatically read in, and the elevation is automatically rasterized into a DEM file, and it is shown in the screen. All that needs to be done is provide a x minimum so we can see the elevation changes better. I set 770 as the minimum. The result is shown below.
   - To adjust the minimum, right click on the layer in Layers, and select Properties. The dialog is shown below.
   - 

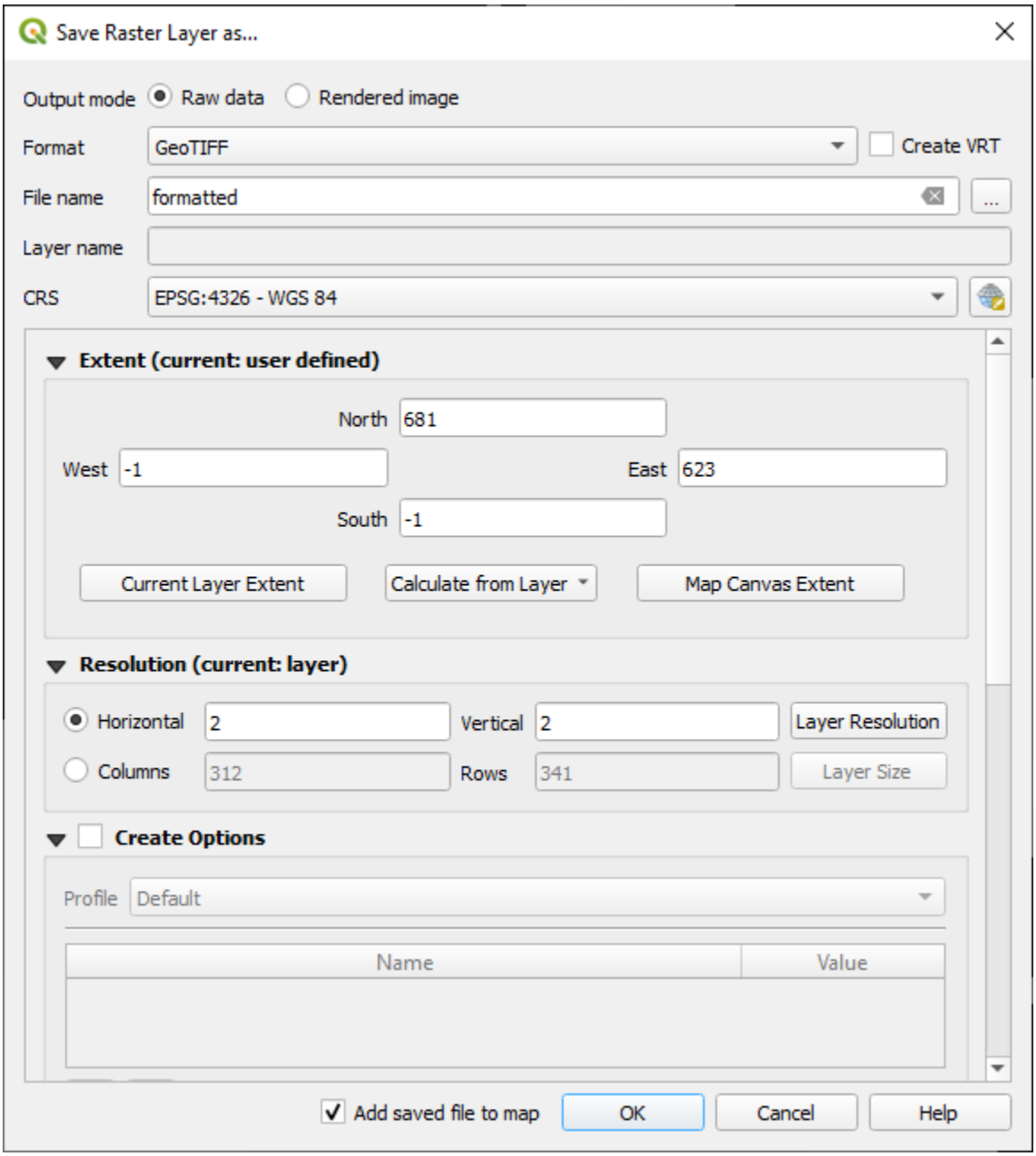
   - Enter 770, or whatever is desired, in the “Min” Line Edit.



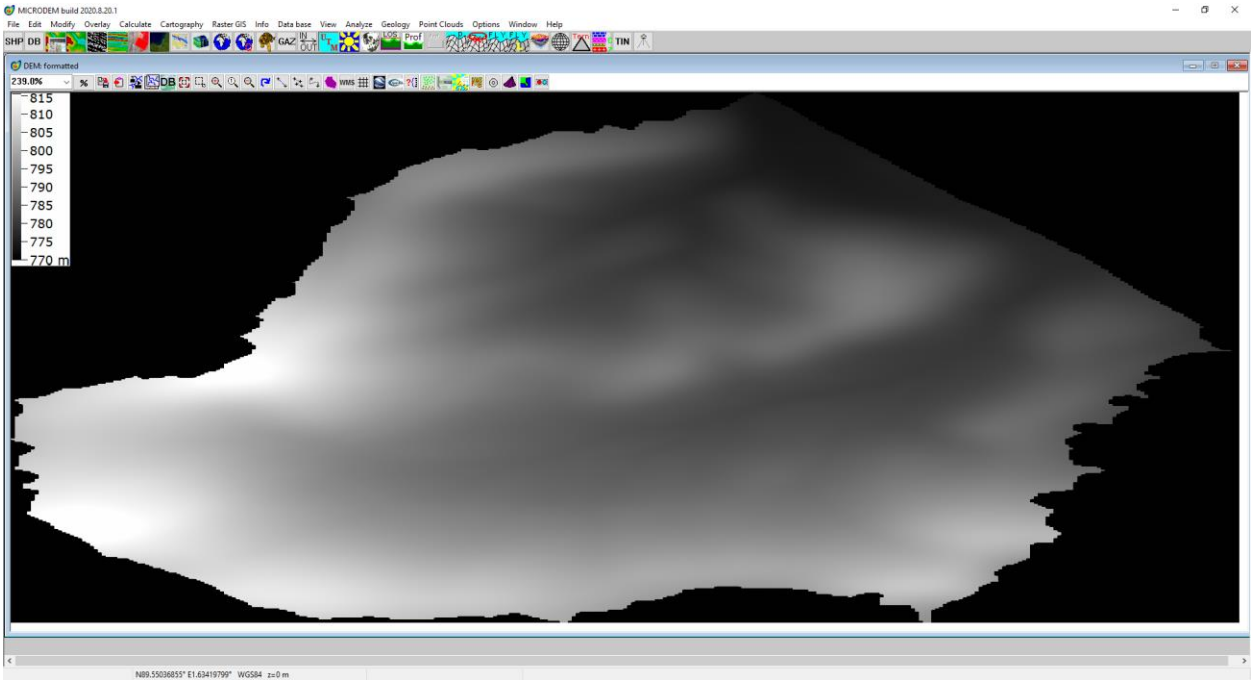
2. Next, we need to create a GeoTiff for this dataset. Right click on the layer, and select Export…, then select save as. The following dialog will open, and the fields were set as shown.

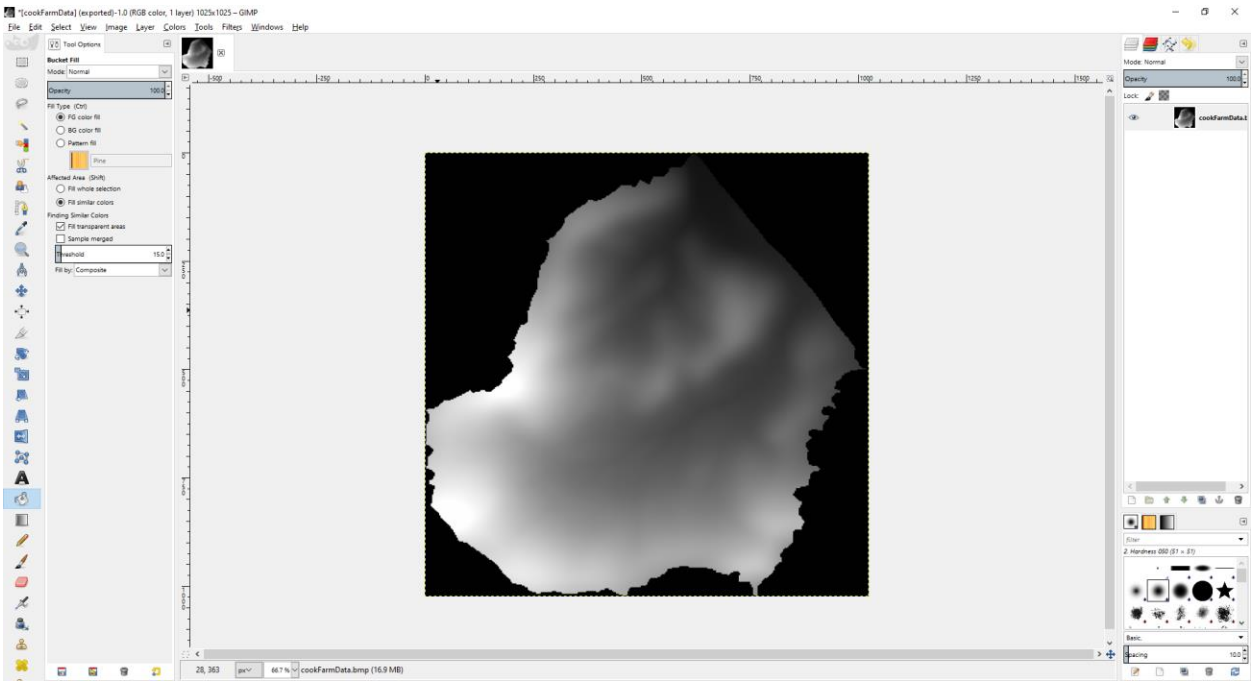


3. For the rest of the procedure, I followed some of the steps outlined for working with MicroDEM above. I just replaced the srtm data with our new formatted data.
4. The following images show my first attempt with MicroDEM using our new data.
   - I ran into an issue here, MicroDEM gave an error, as shown below. I remembered the image above, and though the Extent numbers looked suspicious.
   - I fixed the numbers, and the Save As dialog appeared as follows.
   -

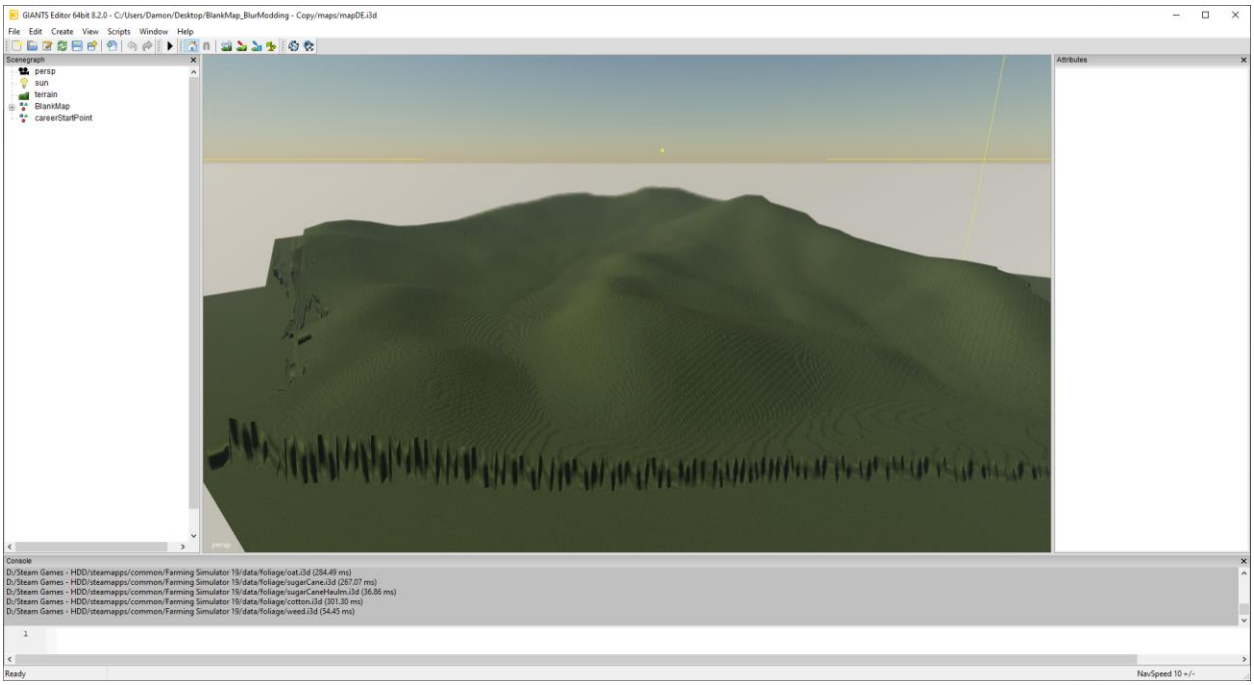


5. Open the GeoTiff file in MicroDEM as described in the previous procedure. Then right click and Display Parameter->Elevation. In this new dialog, select grayscale, and click on zRange. I entered 770 as the min and the automatically generated value was set as the max.
6. Then, since this file does not have the correct coordinates in it, we cannot export to Google Earth in the correct location. So, instead, we will export this image directly from MicroDEM. To do this, select File->Save Image. This will save a .bmp file. The formatted file in MicroDEM is shown below.





7. The .bmp file is not directly readable by the GIANTS editor, so we have to format it correctly. Open GIMP, or your preferred image editing software. Then, open the .bmp file. Rescale the image to 1025x1025px and export the image as a .png file.
8. Open the Blank Map Mod that was downloaded earlier. Inside the Map Mod, open MapDE, and replace the existing mapDE_dem.png with the new .png file. This dem file is the elevation data that is automatically read by the GIANTS editor. At this point, everything is all set. Just open GIANTS editor and open the Blank Map Mod .i3d file. The results in the GIANTS editor is shown below.



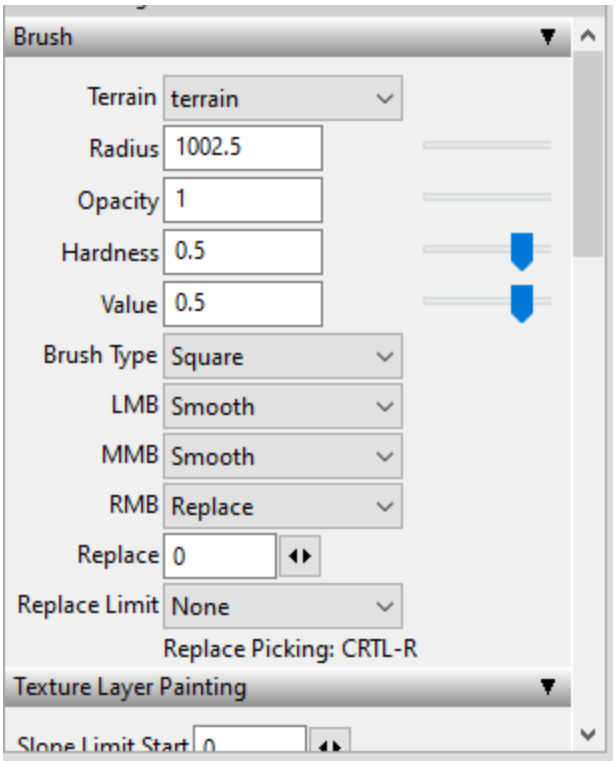
As the result above shows, this was much more successful than our previous attempts. The map represents a real-world landscape. The 2-meter resolution works much better than the previous 30-meter resolution. There are some artifacts here though. For the file to be processed by QGIS, all the -9999 cells in the dataset were set to 0. There was no data for these positions, and these are the cause for the cliff in the image above. The solution to this would be to generate some flat data at the current elevation. This may be done algorithmically, but the GIANTS editor may also have some tools to help with this as well.

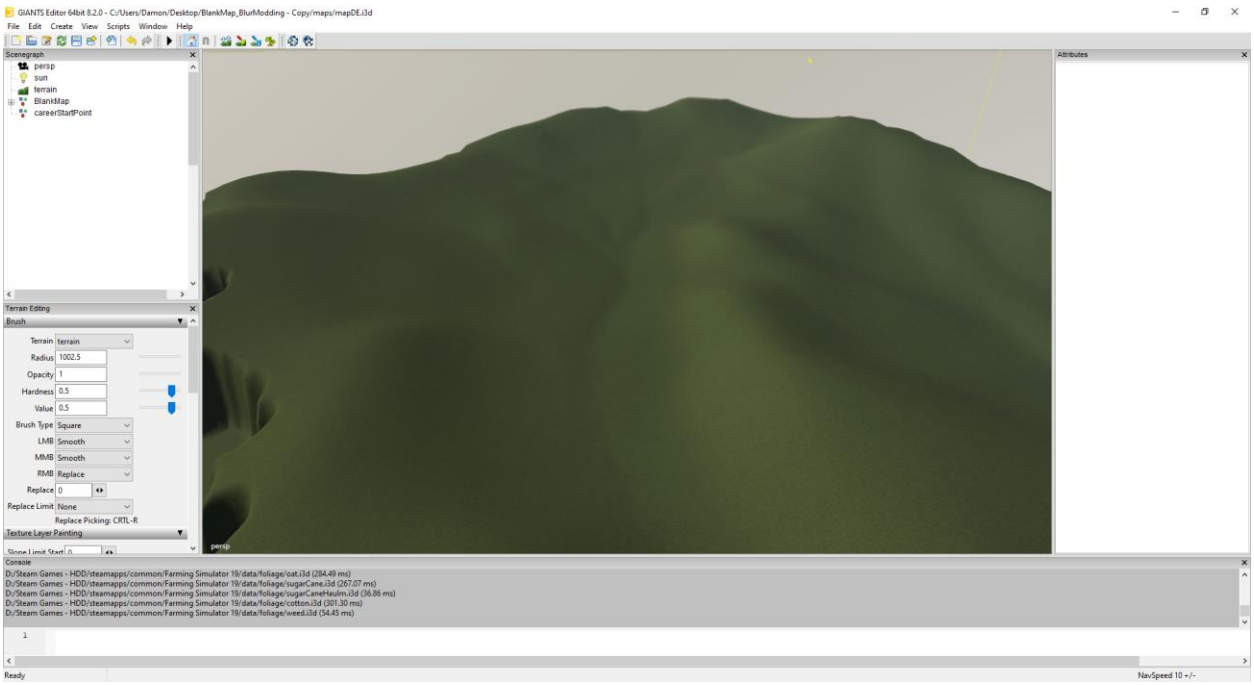
The next steps from here are summarized below.

1. Fix the “cliff” in the dataset.
2. Smooth out the dataset better to reduce the graininess in the data.

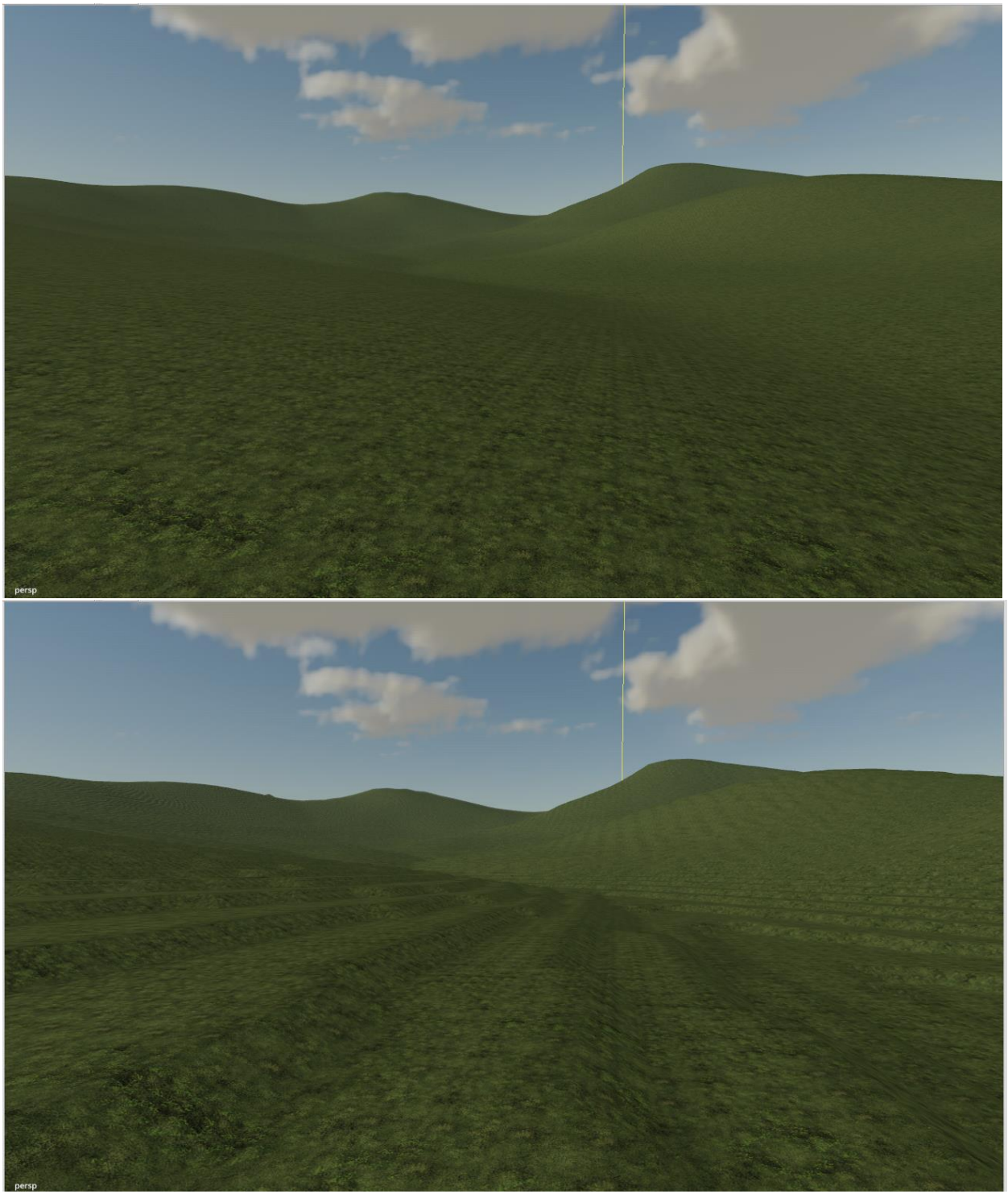
Sept. 22, 2020

To solve the second step, I first tried the built-in smooth tools in the GIANTS editor. If these work well, then I will not have to solve the problem algorithmically. By using the GIANTS terrain sculpt mode  with the following parameters, I created then map as shown below.





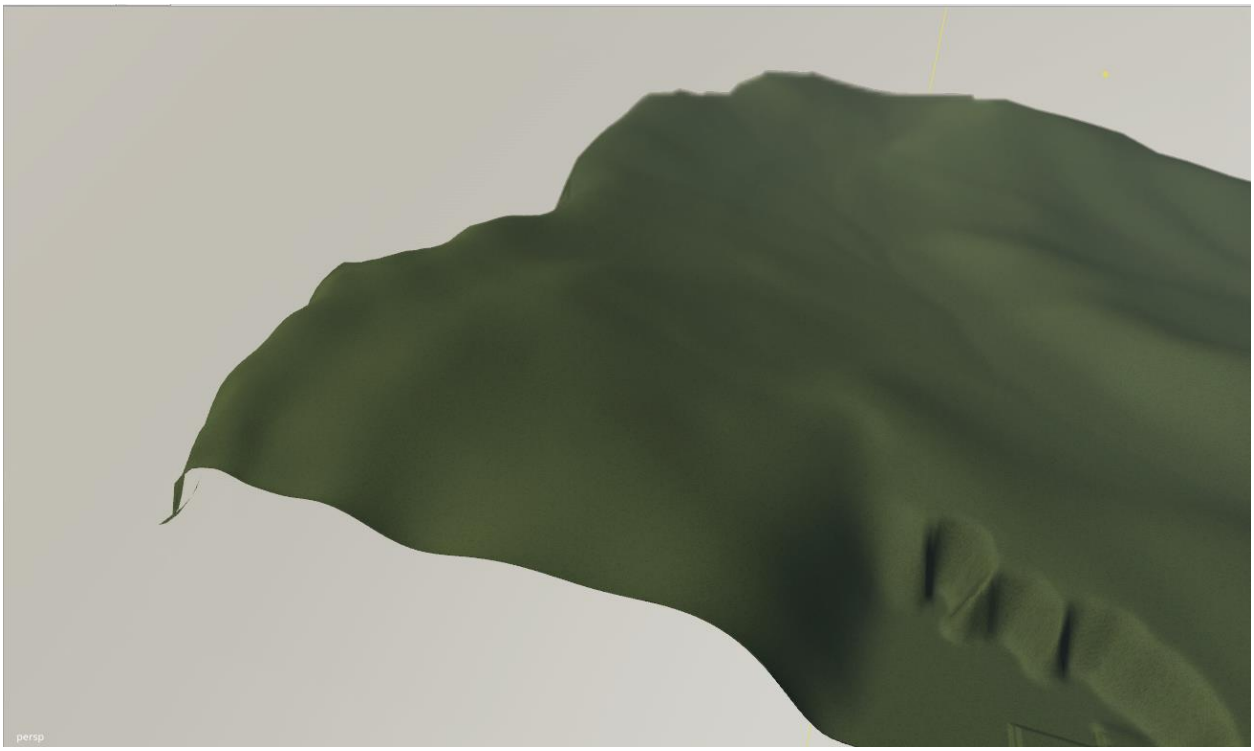
This result turned out to be successful. The built-in terrain tools did well in smoothing out the bumps without losing/mangling the terrain. A comparison is shown below.



As the images above show, the tools smoothed the bumps in a manner that the resulting landscape is virtually unchanged from the original (other than being smoother). The camera was in the exact same position before and after the

smoothing, so it shows how well the result turned out. I doubt that my own smoothing algorithm would do any better here.

The remaining problem to be solved is to deal with the cliffs. Since the terrain tools worked well with the last problem, I attempted to add terrain to the flat sections and smooth them out using the terrain tools. A partial result is shown below.

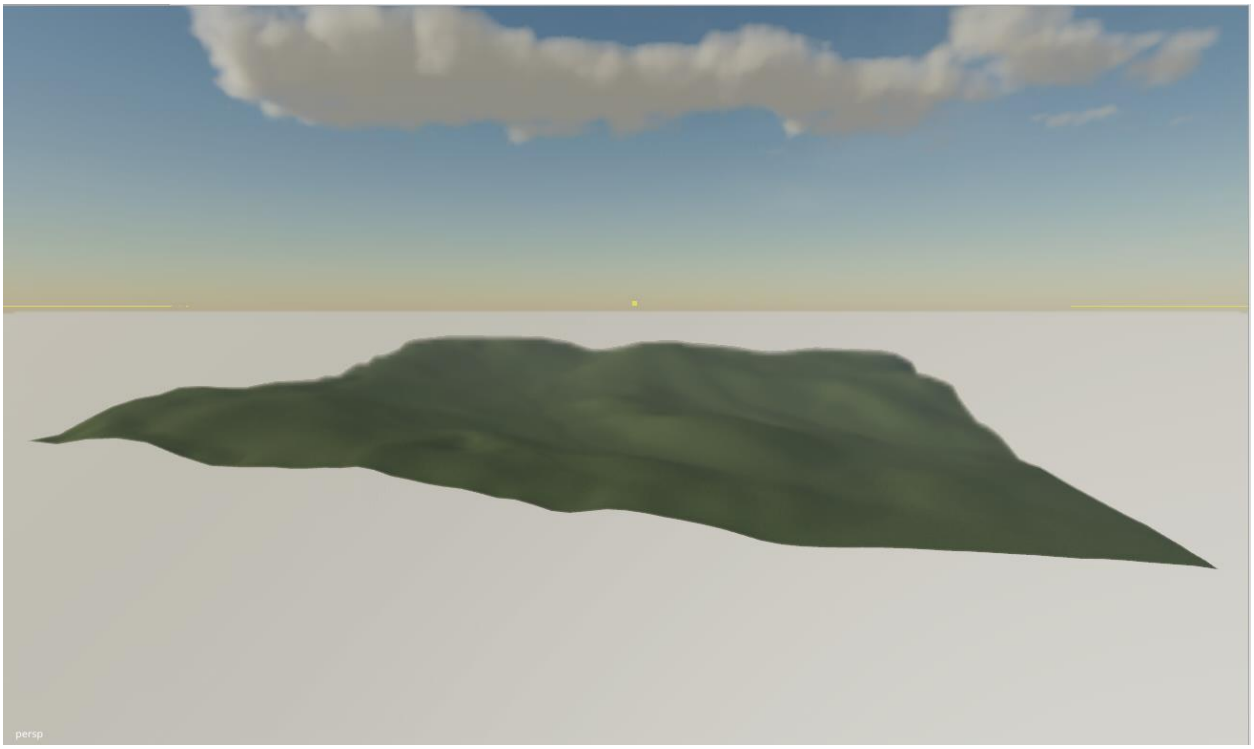


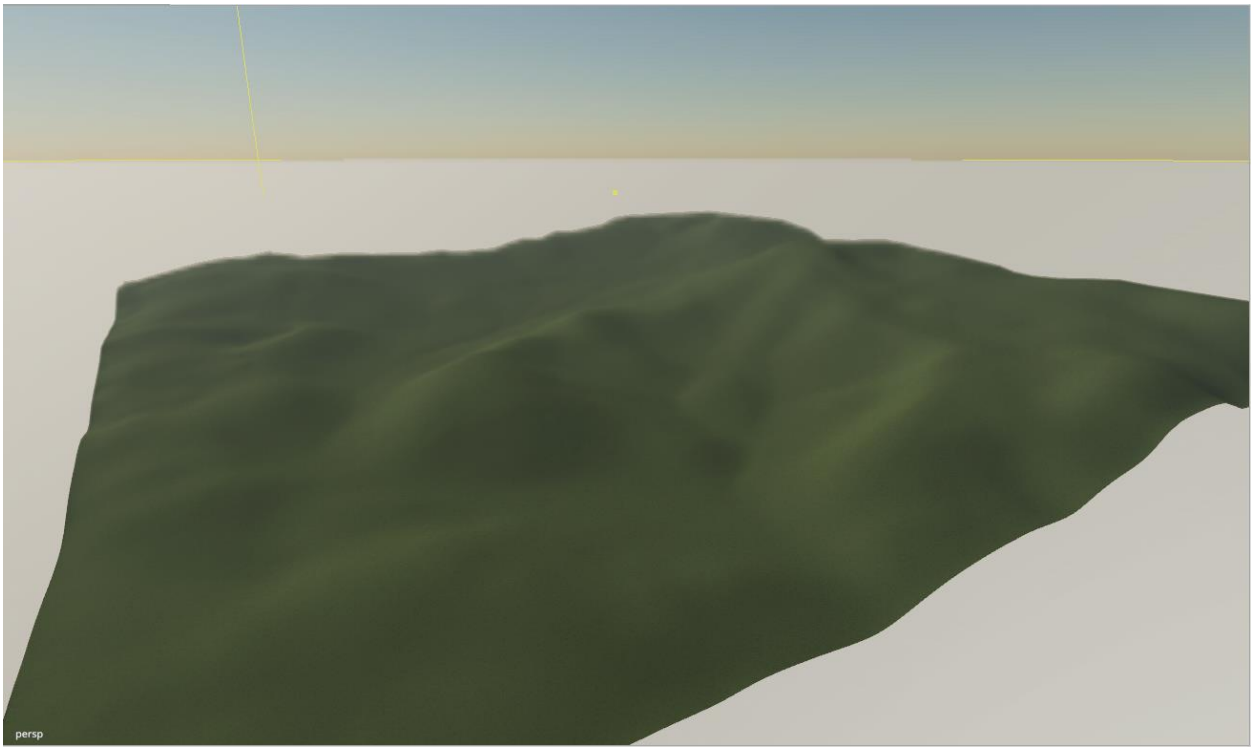
This solution works well to add some real-looking data to the cliff regions. It takes a little bit to do, however. The process involves using the terrain tools to add terrain up to a reasonable level. Then it is a process of adding and subtracting, then smoothing the final result. It appeared as shown in the image for the small section that I did. The terrain does not look out of place with the rest of the data. And since we have no elevation data for those locations, it is the best solution right now.

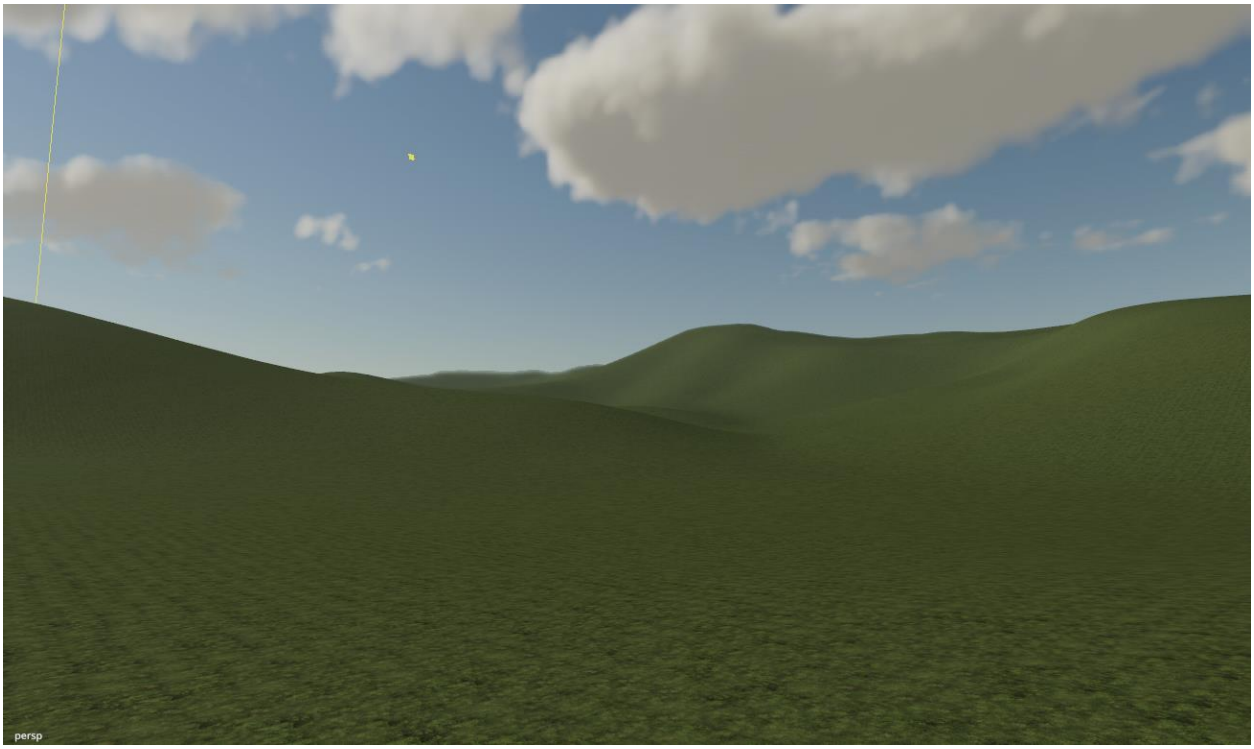
Sept. 25, 2020

I continued the work with the terrain tool to fill in the void sections of the map. The basic procedure is simple. But, it will take some time with using the tools. The plan is to add material with the terrain tools, then smoothing it out

when complete. This is not that easy to do, however, as the terrain tools make it difficult to create a uniform landscape. After some time with the tools, the following map was created.







The final result is the base terrain of the map that will be used for the rest of this project. This may be remade later on, however, for now this map has been saved and will be used.

The next steps for this map would be to decorate this such that the field looks like the actual Cook Farm. This includes the following.

1. Roads
   - I will take a look at the real-world positions of the local roads and try to place them correctly.
   - I also need to research/investigate how to correctly create roads in the GIANTS editor.
2. Farms and crops.
   - Given the real-world locations of crops, and specific requirements from our sponsor, I will place several crops and fields on the map.
   - These will be where the auto-pathing algorithms will be deployed at.
3. Structures and Buildings
   - These will correspond to any of the Cook Farm barns, storage, or other facilities on the property.
4. Terrain painting.

- This step is optional. If I am given satellite view or a photo of the location, I can attempt to paint regions of the terrain to better reflect the real-world location.
- I also might just look at some of the other farming simulator maps and see how they decorated the map and do this for our map.

Once all these items above are added to the map, and the map is adequately "decorated," then the map itself is done.

Sept. 26, 2020

In preparation for continued work on the map, I read through the *Farming Simulator Modding for Dummies* book that can be found at https://github.com/palouse-agriculture-in-virtual-reality/FS-19-Cook-Farm-Mod/blob/develop/Documentation/Farming Simulator Modding for Dummies.pdf.

I covered chapters 1-3 and took notes by hand. Covered concepts of navigating the editor, triggers, terrain editing, and placing farmable land and crops.

Sept. 29, 2019

I watched some GIANTS editor tutorials located here https://gdn.giants-software.com/videoTutorials2.php. I started at video 3 since I already covered the really basic concepts in the book. I also covered some more chapters in the book, starting at chapter 3 and ending at chapter, skipping chapter 5. This was skipped since it covered particles, which are not useful for this project.

Sept. 30, 2020

I continued working with the book, making it to chapter 12 skipping some of the chapters in between which go into detail about modelling and other cosmetic information.

Oct. 2, 2020

I worked with familiarizing myself with Lua scripting and the GIANTS editor. To do this, I looked at some official tutorials listed below.

1. Lua Scripting Intro. https://gdn.giants-software.com/tutorial01.php

Oct. 6, 2020

Attended a group meeting today at 3:30. Talked about some Lua programming, and potentially working with another language and environment to develop the initial pathfinding algorithm.

With the previous map goals acknowledged, today I begun working on roads. There are multiple steps to this, but the first includes finding the real-world positions of the roads.

The question or problem to be solved here is to locate the real-world positions of the roads in their appropriate positions in our map. The first idea I had was to open Google Earth Pro and move to the location where our map is located. From here, my hope is that I can visually match the GIANTS map to the Google Earth map. Spent most of the day researching how to convert the coordinates in our data file to Google Earth. This will help us visualize the data.

I discovered that this data file is a ESRI ASCII data grid, and the coordinates given are not directly readable by Google Earth. It needs to be converted from the WGS84 Zone 11 coordinates to the coordinates that Google Earth understands. This took most of my time, and I did not make any additional progress.

While I was researching, I found some important data about the coordinates of the dataset. The file given has two values for a reference coordinate, xllcorner and yllcorner. The following page discusses these in detail.

http://resources.esri.com/help/9.3/arcgisengine/java/GP_ToolRef/spatial_analyst_tools/esri_ascii_raster_format.htm

From this page, I discovered that these coordinates are the lower left corner of the dataset.

Oct. 13, 2020

I sent an email to our sponsor Dev to ask for some more details about the dataset. More specifically, I wanted to know about the coordinates system used to help me solve my previous goals. Dev responded later, informing me that the coordinates used are in UTM format, zone 11. And he also sent a link for a calculator that I can use. This is included as follows.
https://www.engineeringtoolbox.com/utm-latitude-longitude-d_1370.html

Oct. 19, 2020

I began work on converting the coordinates to a format readable by Google Maps. Using the information from Dev and the data sheet, I filled out the website as follows.

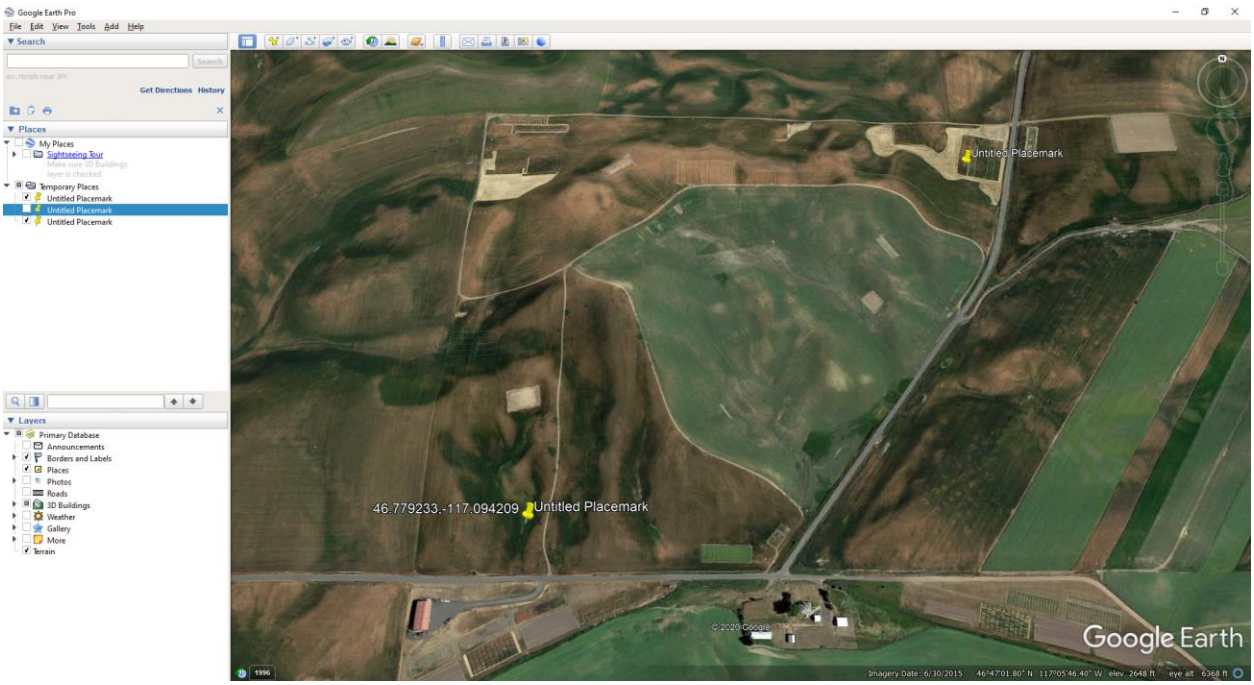
From my previous work, I remembered the coordinates to be around 46, -117, and the calculator found a result close to this. So, for the next step, I went ahead and put a point in Google Earth Pro. This is shown below.

This is a correct position, and to the best of my knowledge, accurately represents the bottom left coordinate of the data set. With this point on the map, the next step is to find the top right point of the dataset. With some math, this is computed easily.

For this specific dataset, we are looking at the Cook Farm West location in a 2-meter resolution. Given the number of rows and columns, we can compute the location. After completing this computation, we plotted the top right point. For future reference, I included all the points in the coordinates below.

1. Bottom Left
    a. 46°46'45.24"N
    b. 117° 5'39.15"W
2. Top Right
    a. 46°47'5.55"N
    b. 117° 5'7.02"W

The plotted points in Google Earth Pro showed the extents of the datasheet. This is shown in the following image.



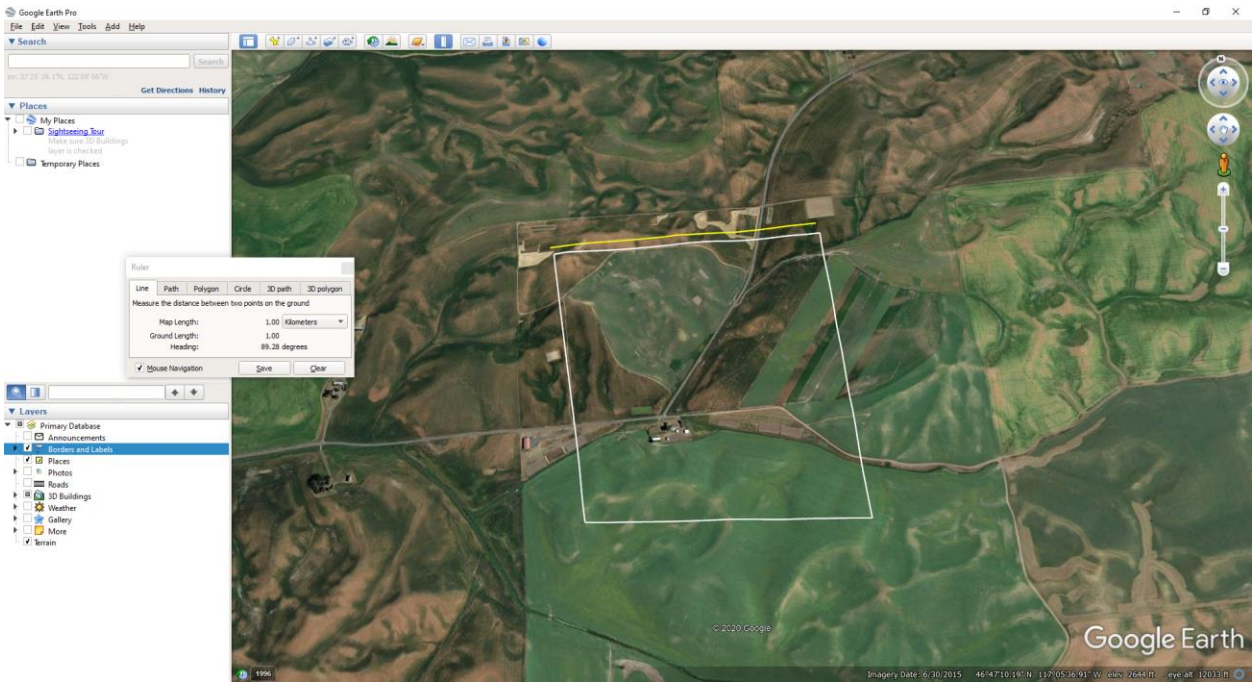
Oct. 26, 2020

When investigating the map, some issues were found. The largest issue is that the scale of the region of space in the data set is not equal to our Farming Simulator map size. To review, we create a 1km by 1km map in Farming Simulator. There may be some ways to change this, but with my experimentation, even using a 1024 resolution image will not be read by the GIANTS editor. Opening an incorrectly formatted DEM file for the terrain results in GIANTS editor not loading the map. So, for right now, we are limited to the 1km map size. There are sources claiming that a 2km map size is also permissible, but that does not help us in this situation.

For the Cook Farm West map, we have a size of 682m by 626m. This, of course, does not equal the Farming Simulator map size. To resolve this solution, some options are presented.

1. Get additional map data for the missing part of the map. If we look at the Google Maps image, we can see that we need to get quite a bit

more data.



a. By looking at the rough square and comparing this to the two reference points for our data set, we see that we have approximately 40% of the map region missing from out data set.
b. This solution involves getting data points for adjacent locations, adding on top of our existing data, resulting in a mapped 1km square.
c. This solution involves manual data gathering (expensive) or getting data from online. However, with my previous experience with finding high resolution data for this location, this is not a viable option.
d. Another potentially good part about this solution, is that we can use some of the Cook Farm East data to populate the missing data. Looking at the image, we cannot fit the entire east farm into the 1km square, so this might not be that viable.

2. Scale the existing region captured by the dataset to a 1km square. This is what we are currently doing. This is a good option because it captures the essence of the map, without requiring more data. Even though the terrain will appear larger than in real life, the main idea of the terrain is still captured.

3. Create arbitrary data for the missing region. This solution means importing the data set at its original scale, leaving the rest of the unmapped locations blank. I can then go into the GIANTS editor and use the terrain tools to manually generate arbitrary terrain that looks real, and fits with the surrounding, existing terrain.
    a. This solution will change the “essence” of the map, as it introduces new terrain which may not make the map resemble the farm.
    b. Cheap and easy, however. Might be viable if there is more focus on the mapped sections of the map.

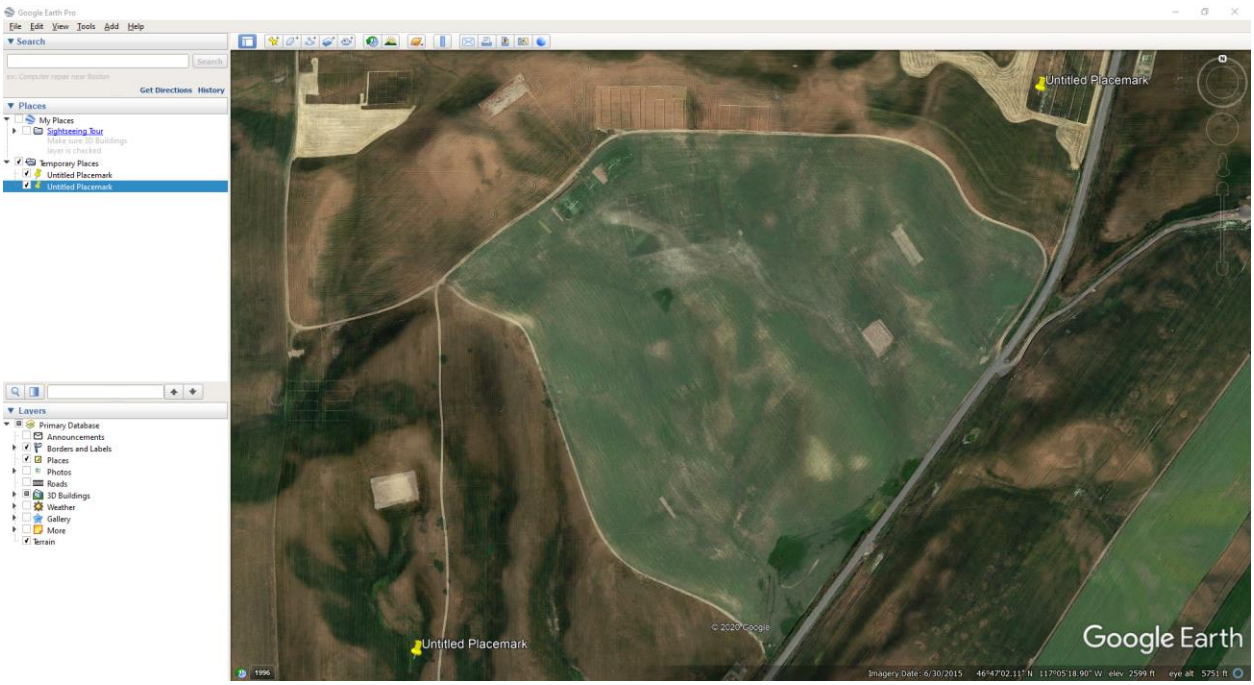
Considering each of these options, we are going to continue with the scaling option. It has already been implemented, and makes the most sense. I will consult my team on this in the next meeting, however.

The next goal is to work with roads and add roads to our map.

Oct. 28, 2020

The idea right now to get roads on the map is to get the same region of space from Google Earth. Take a screenshot of that space and overlay it with some transparency over the existing map DEM file. The procedure is included below.

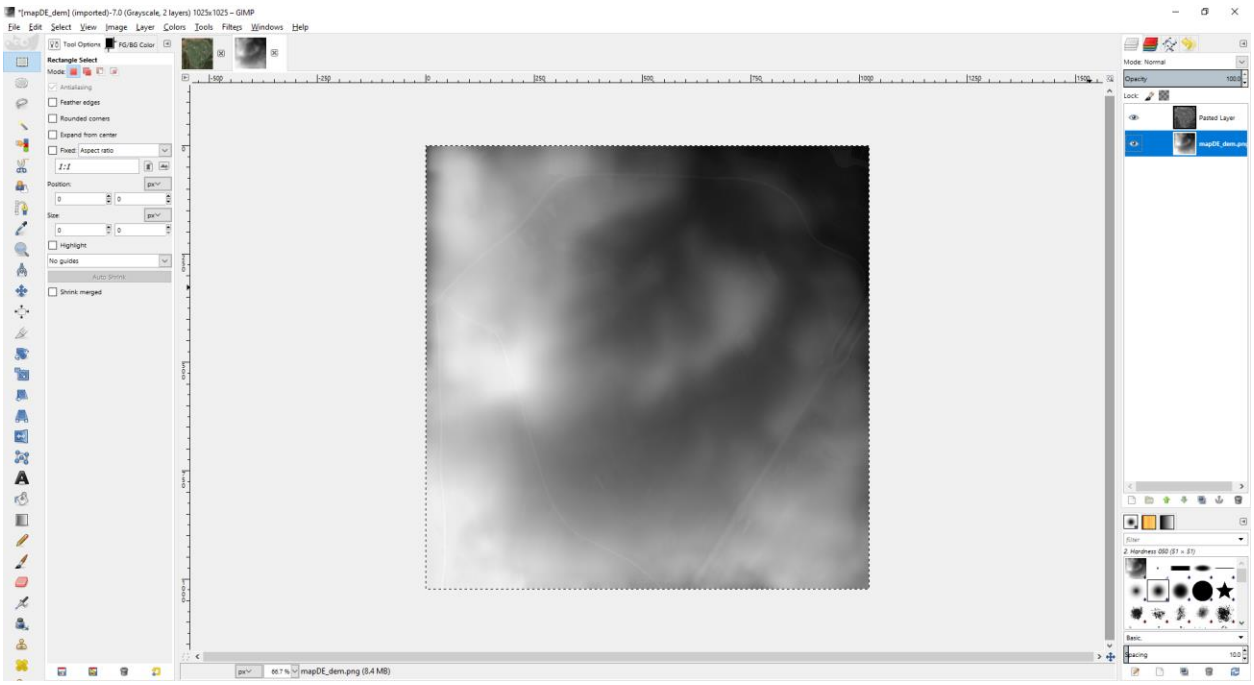
1. Open Google Earth and navigate to our location. Place points at each of the two coordinates we have as reference. It should look as follows.



a. To get the best results, verify that this view is a top-down view of the location, without any skewing. Then get the region of space maximized within the map view. This ensures the highest resolution possible.
b. I then took a screenshot of the map region corresponding to our dataset. This is shown in the following image.

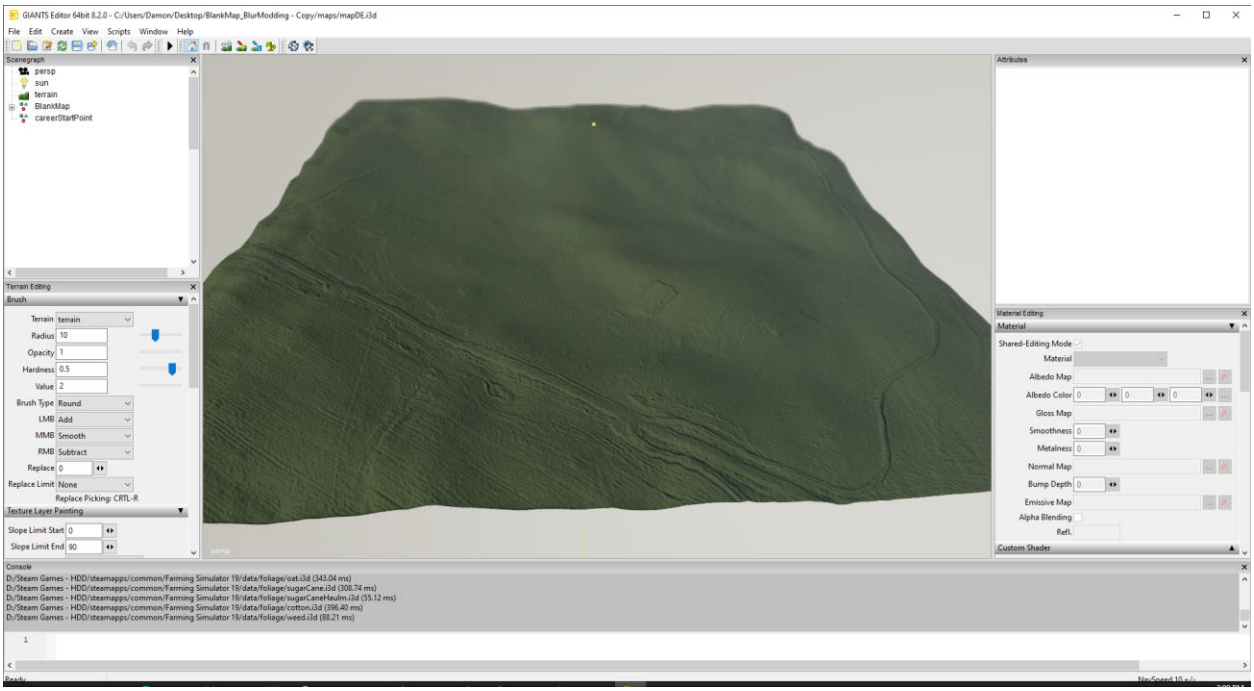
c. 

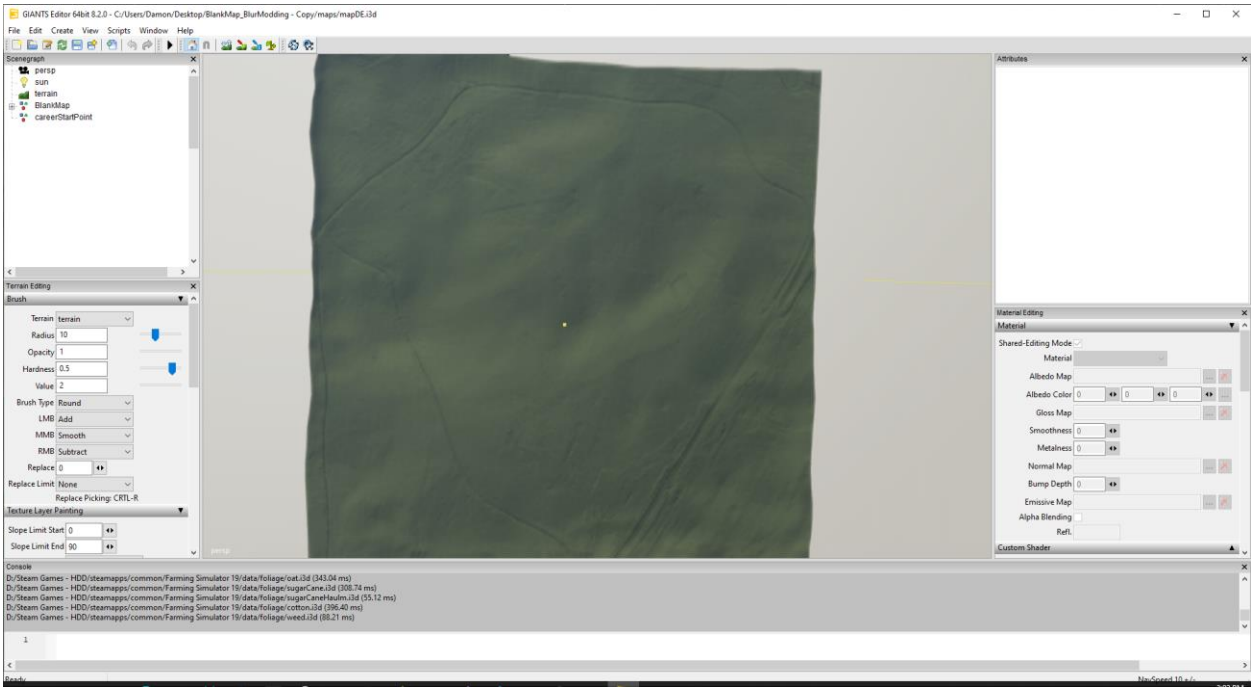
2. Then open the DEM file for the map in a photo editor but put this aside for right now. Again, we are using GIMP. This file is 1024px by 1024px, and the screenshot we just took does not match this. Open this file by itself, then resize it to this size.
3. Once this other screenshot has been resized, copy it and paste it on top of the DEM, then put it in its own layer. Modify the transparency of this layer to be 10%. It will look as follows.



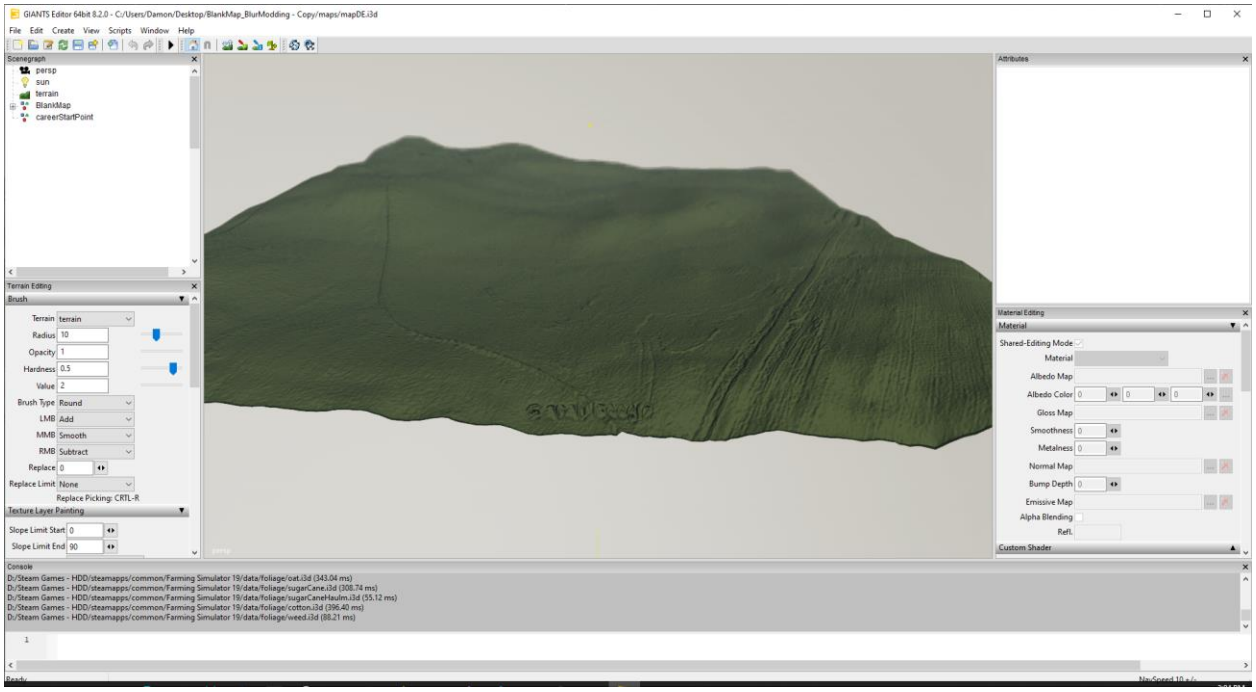
a. As you can see in the photo, there is a slight overlay of the roads and other map features from Google Earth that is visible. Save this dem as a new file, to not overwrite the original. Then rename this new file as mapDEM.png.

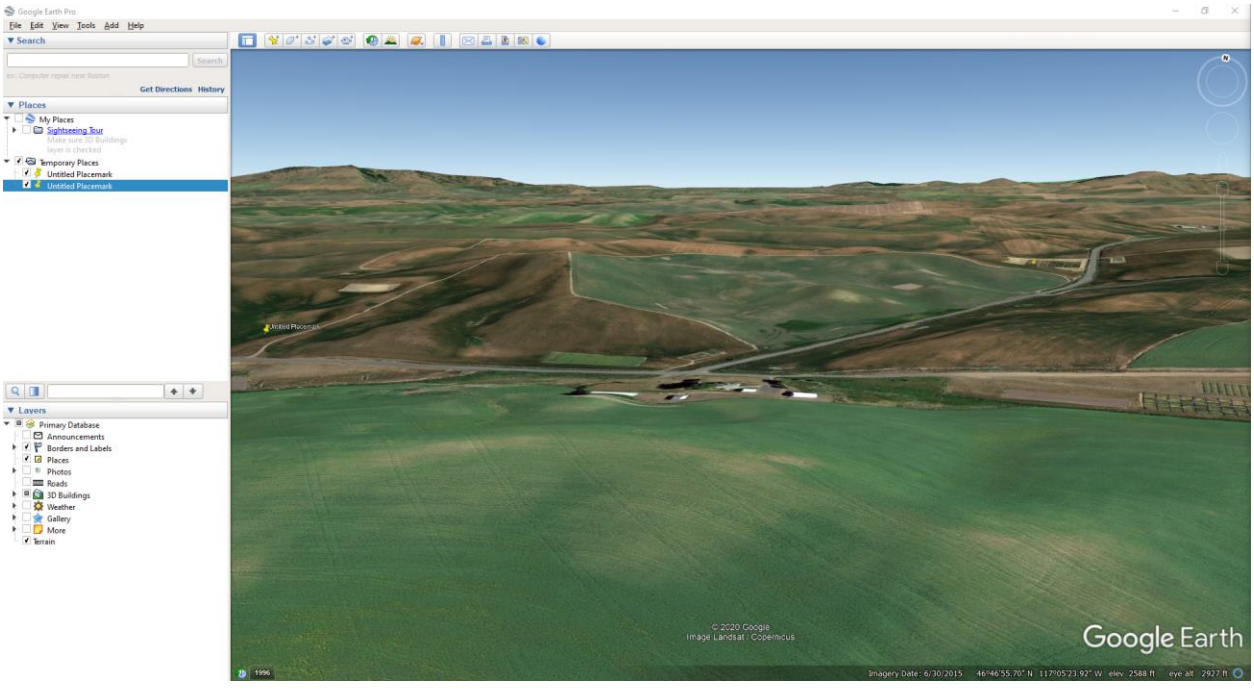
4. Open up GIANTS editor for the map that has this DEM file. The opened map is shown as follows.





5. The visible lines in the image correspond to the roads, and since we can see them, we can use the terrain painter to paint where the roads are. This is exactly what I did, while using Google Earth as reference.
6. As I started doing this, I wanted to compare the elevation to Google Earth, to verify that the orientation of this data is correct. I noticed that they do not match, and I need to rotate the DEM file, or I can rotate the roads. The following images show this.





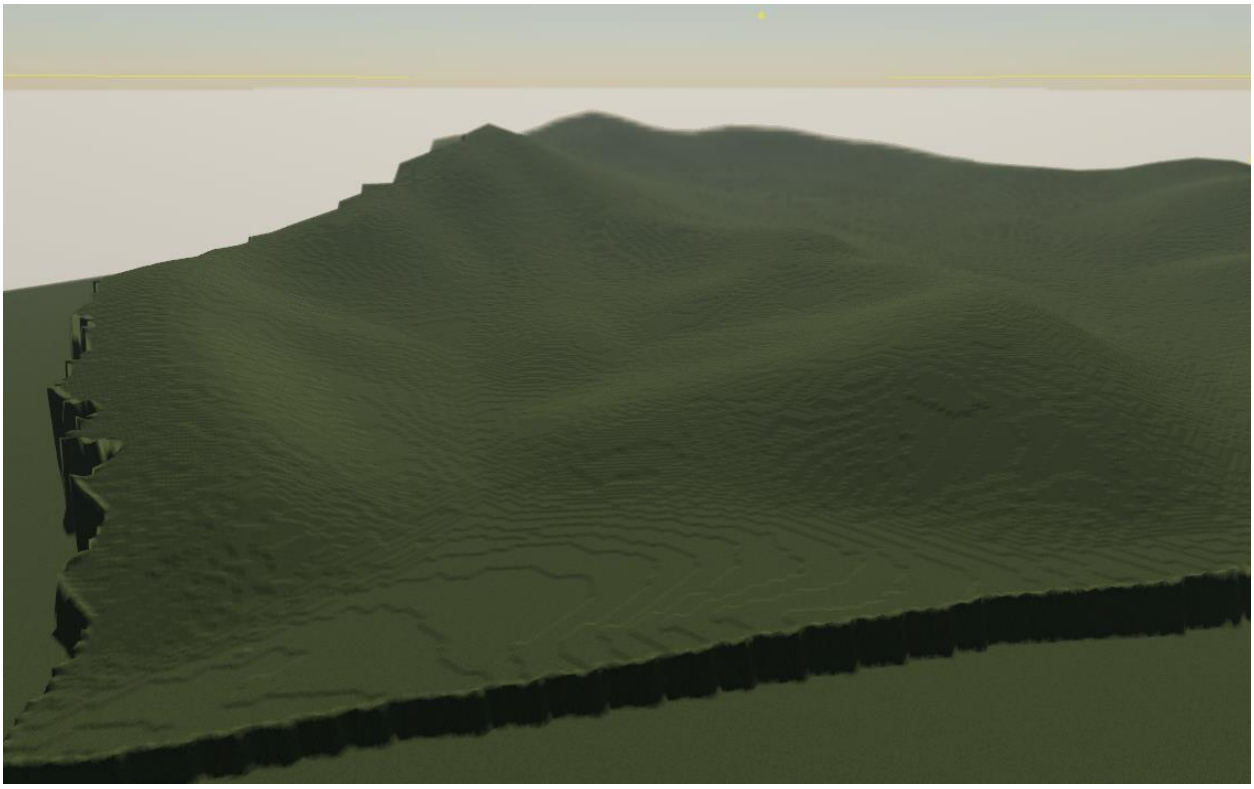
a. As the images show, the road on the left that follows the ridge of the hill does not follow it in GIANTS editor. We can see that ridge in the map, however. I rotated the road overlay in GIMP.

Nov. 9, 2020

I was finally able to recognize the data in Google Earth. Take a look at the following images.

Google Earth

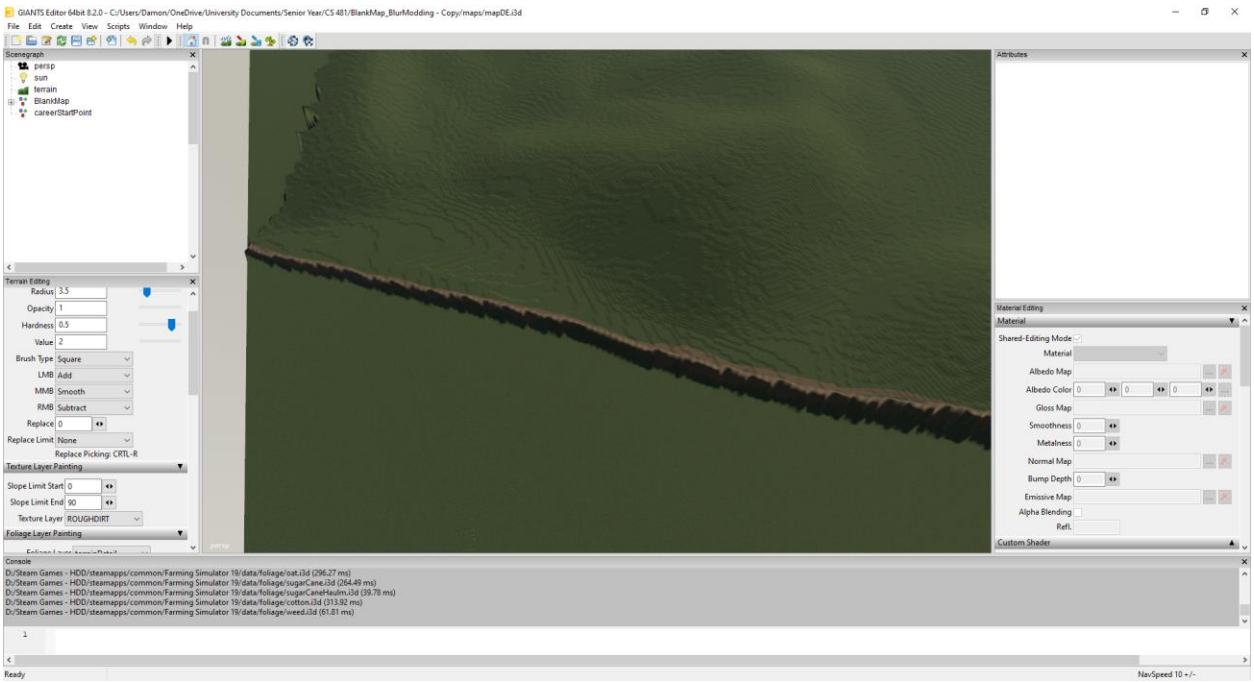
GIANTS



The relation can be seen. The edge of the data set on the left roughly matches the road. We can see the valley in the middle clearly. Now that I can confirm the data, and that it resembles the real-world location, I can begin work on getting those roads into position.

Nov. 10, 2020

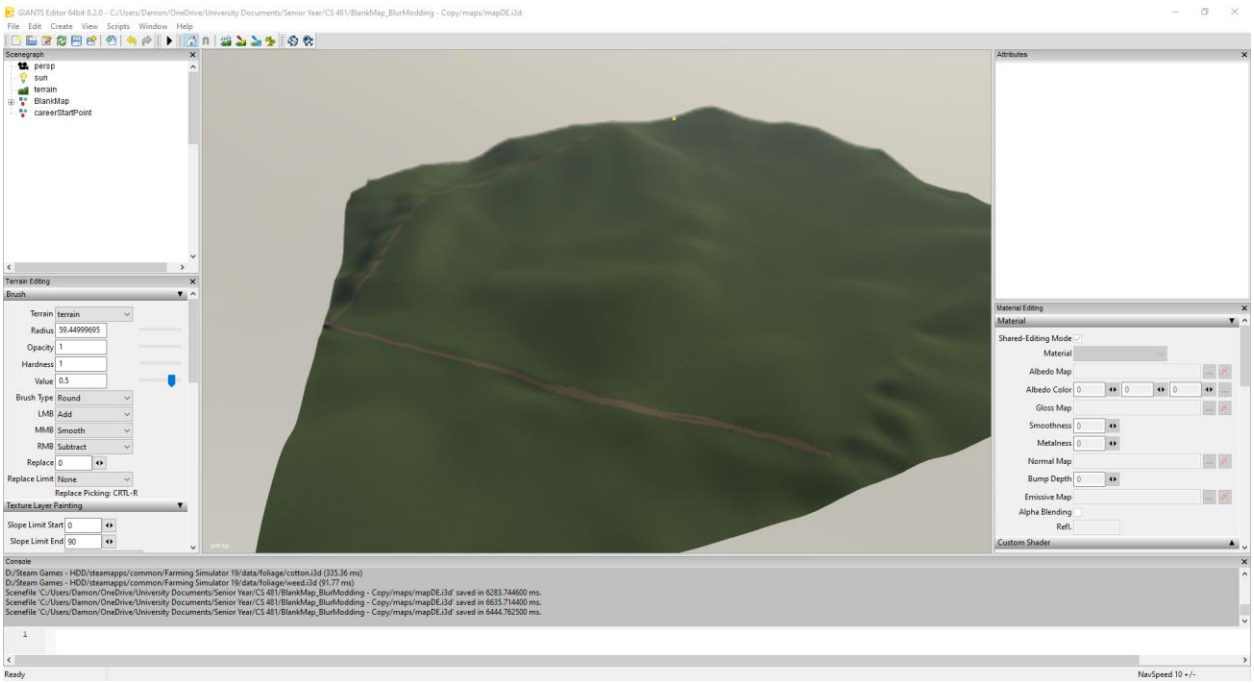
The goal is now to fix the given terrain and add some more terrain. First, however, let us mark the positions of the roads.



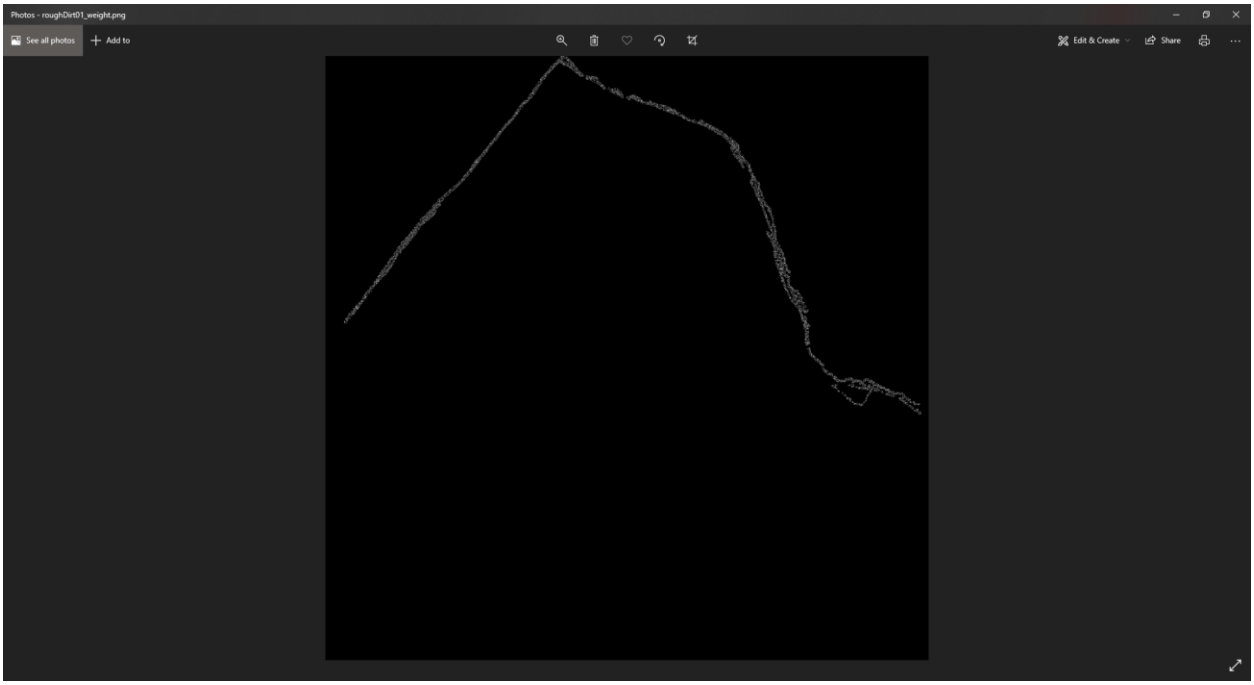
I painted a dirt-type texture along the rough road line to mark its position after I change the surrounding terrain. I continued to do this for all the other borders with roads, or at least those that were obvious.

Nov. 11, 2020

I worked on, once again, creating terrain for our blank sections that better represents the actual terrain. The results appear as follow. Note the terrain marking the rough road positions.



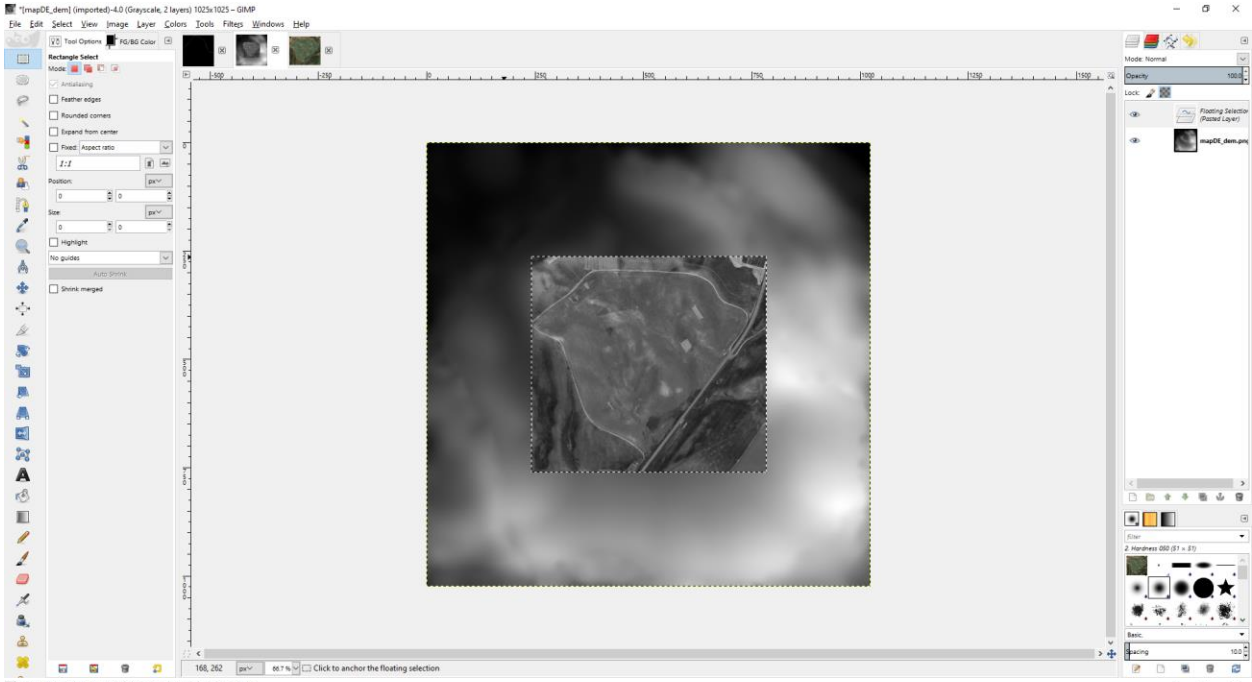
This better represents the actual real world terrain, and we can use the paint markings to better line up the roads. There is a layer image, called roughDirt01_weight.png that contains the lines of the markings in relation to the map. This is shown below.



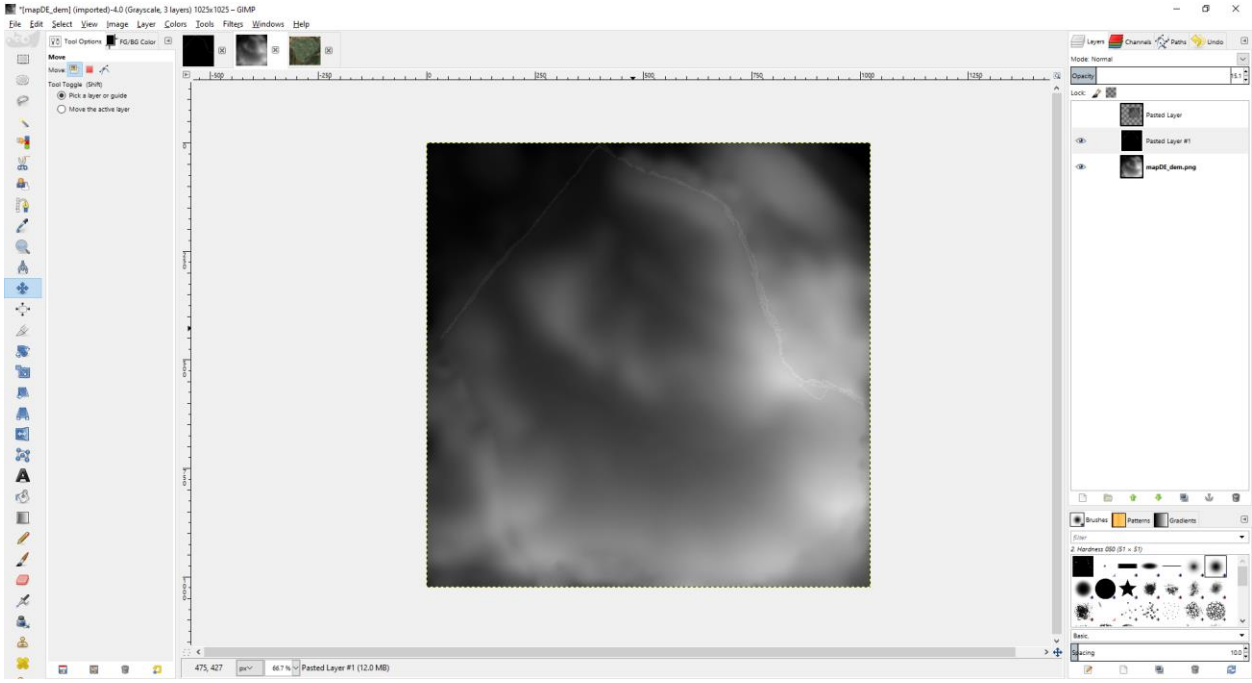
The idea is to now do what we did earlier and compare this to the actual position, or approx. position, of the roads in relation to our map in Farming Simulator. I did the following.

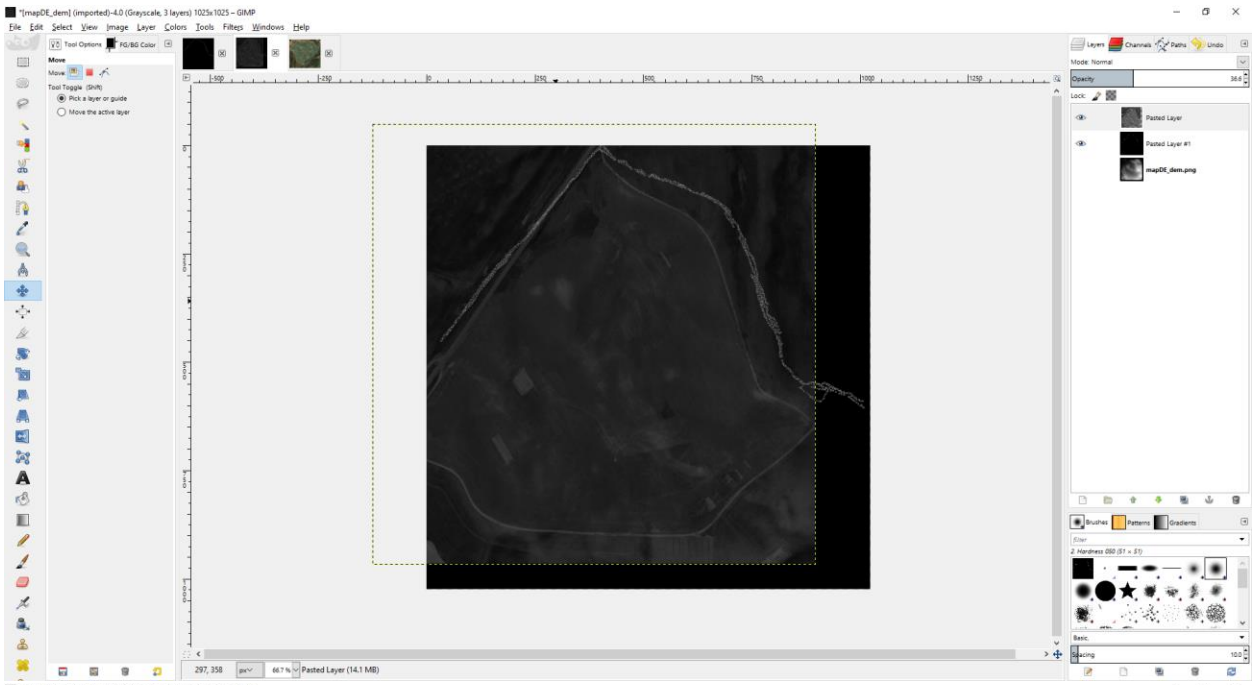
1. Opened the MapDEM and roughDirt01_weight files in GIMP.
2. Took a screenshot of the Google Earth region within the extents of the map space. This is shown below.
   a. 
   b. Follow the steps previously described.

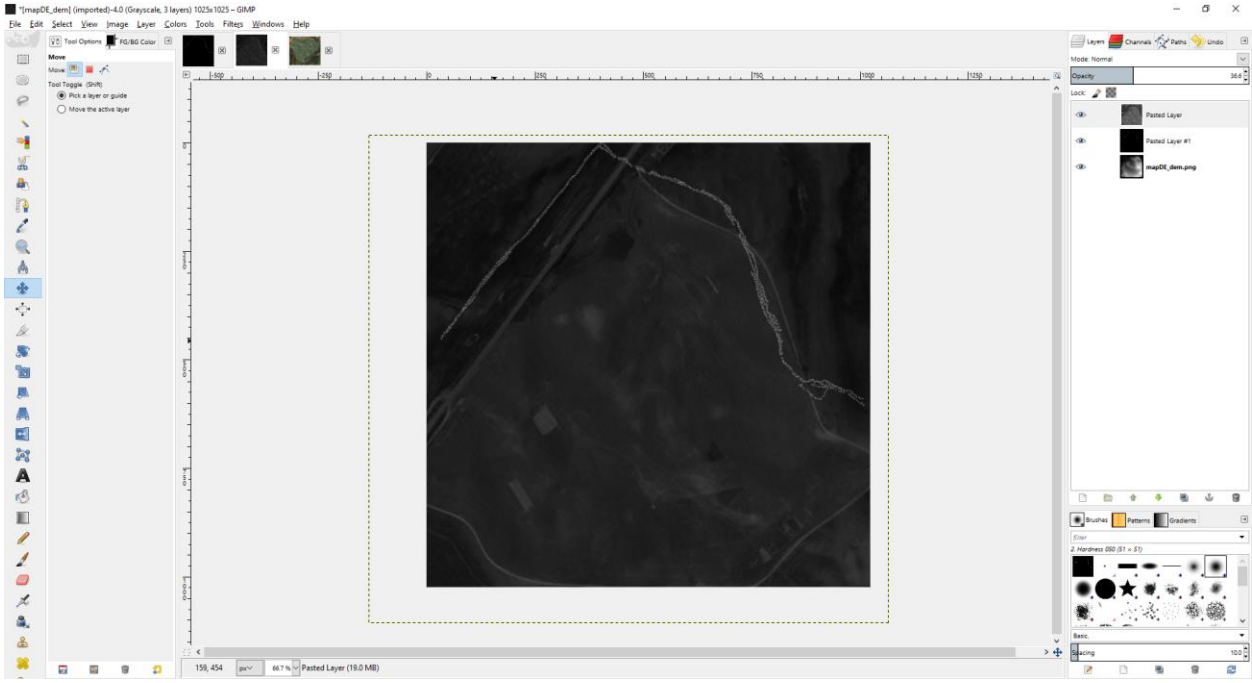
c.


"[mapDE_dem] (imported)-4.0 (Grayscale, 2 layers) 1025x1025 – GIMP
File Edit Select View Image Layer Colors Tools Filters Windows Help
Rectangle Select
Feather edges
Rounded corners
Expand from center
Fixed: Aspect ratio
Highlight
Shrink merged
Mode: Normal
Opacity
Lock:
Floating Selection (Pasted Layer)
mapDE_dem.png
168, 262
66.7 %
Click to anchor the floating selection

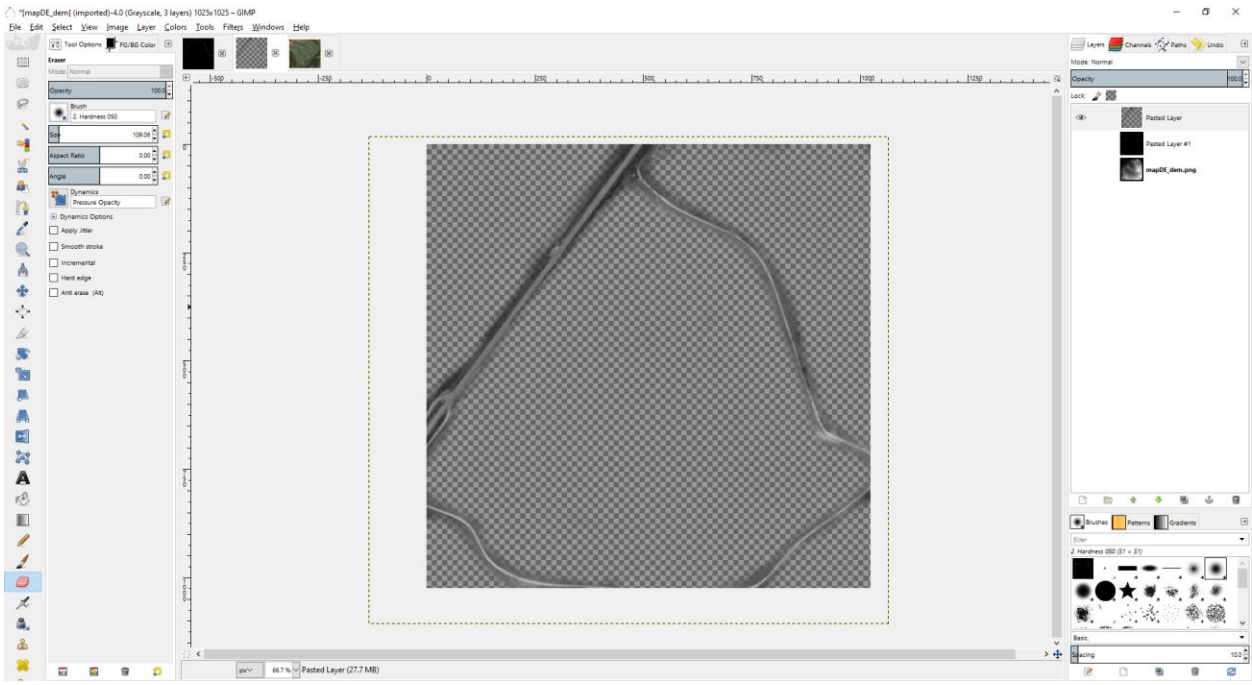
d.


"[mapDE_dem] (imported)-4.0 (Grayscale, 3 layers) 1025x1025 – GIMP
File Edit Select View Image Layer Colors Tools Filters Windows Help
Move
Tool Toggle (Shift)
Pick a layer or guide
Move the active layer
Layers Channels Paths Undo
Mode: Normal
Opacity
Lock:
Pasted Layer
Pasted Layer #1
mapDE_dem.png
Brushes Patterns Gradients
475, 427
66.7 %
Pasted Layer #1 (12.0 MB)

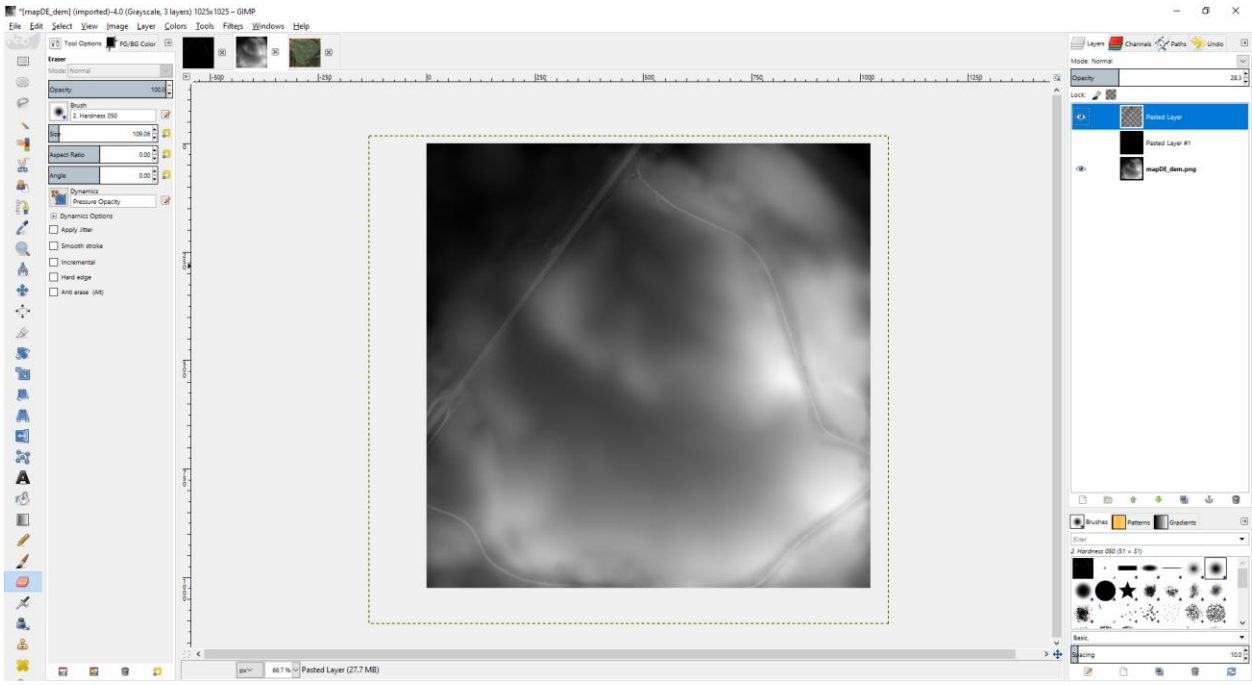
e. 

f. 

g. To lessen noise from the image, I went ahead and erased most of the map parts, other than the roads. The image below shows the result of the image, it just shows the roads now.

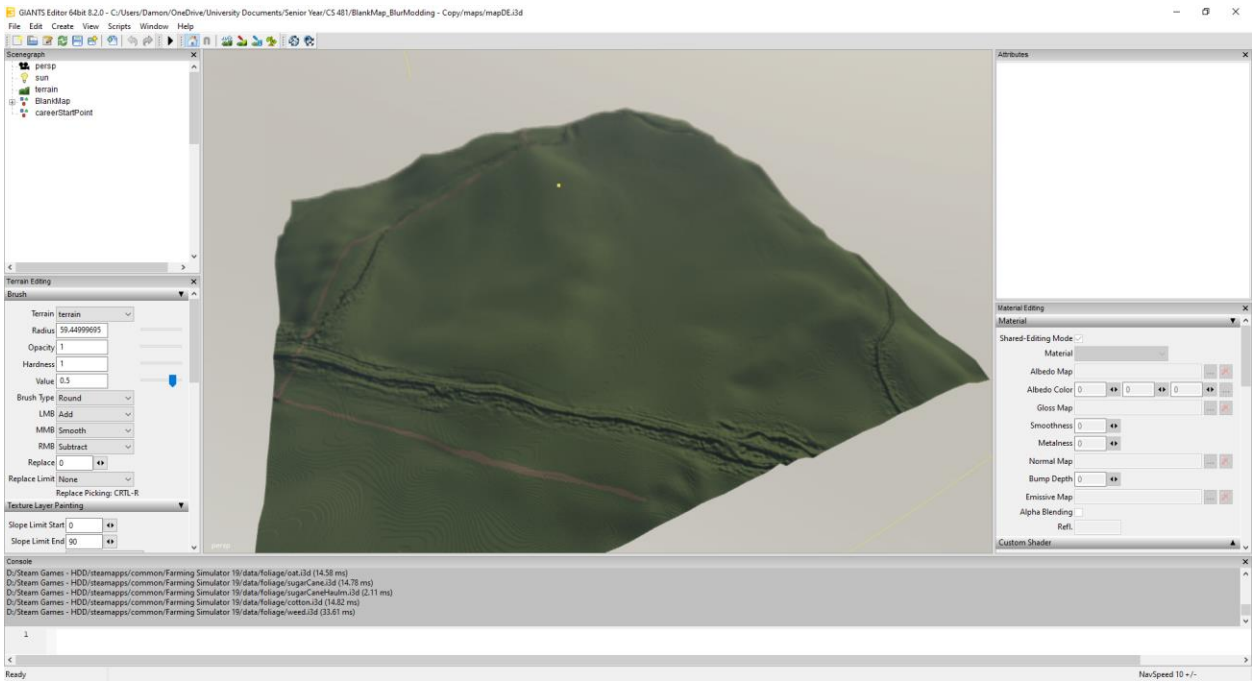
h. 

i. When this image above is overlayed on top of the DEM, it looks as follows.

j. 

k. The road image has a lower opacity, and I started with just under 30% opacity. I created a new image to set as the new DEM in GIANTS. I am only briefly covering this now because all these steps are in detail above.

3. I then opened the new DEM in GIANTS, and the result is as follows.

a. 

b. This result is not optimal. I see that a smaller opacity would be better, and that the roads missed the mark. I know this because in Google Earth, the road on the left side is supposed to follow that ridge, and turn at the highest point in this data set. It does not do that in the image.

c. 

4. I made another attempt at this, trying to fix the extents of the image.

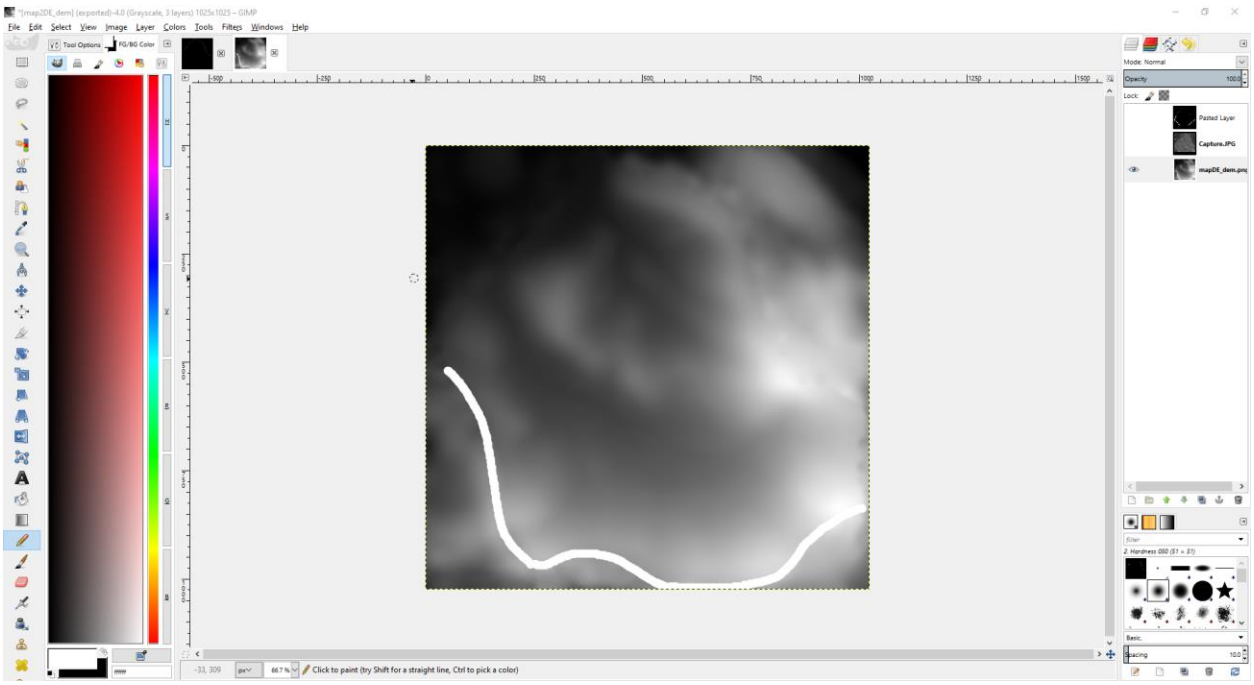
a. 

b. Notice the extent1, extent2, extent3 which better fit the actual extents of the dataset.

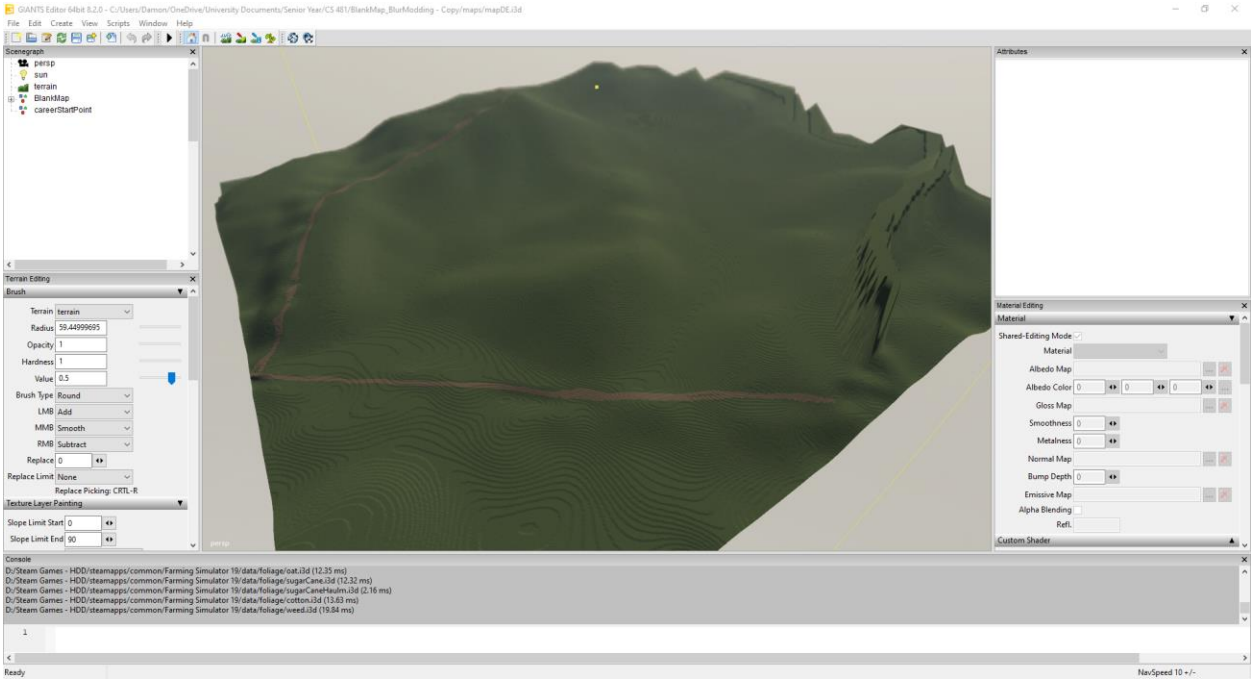
c.

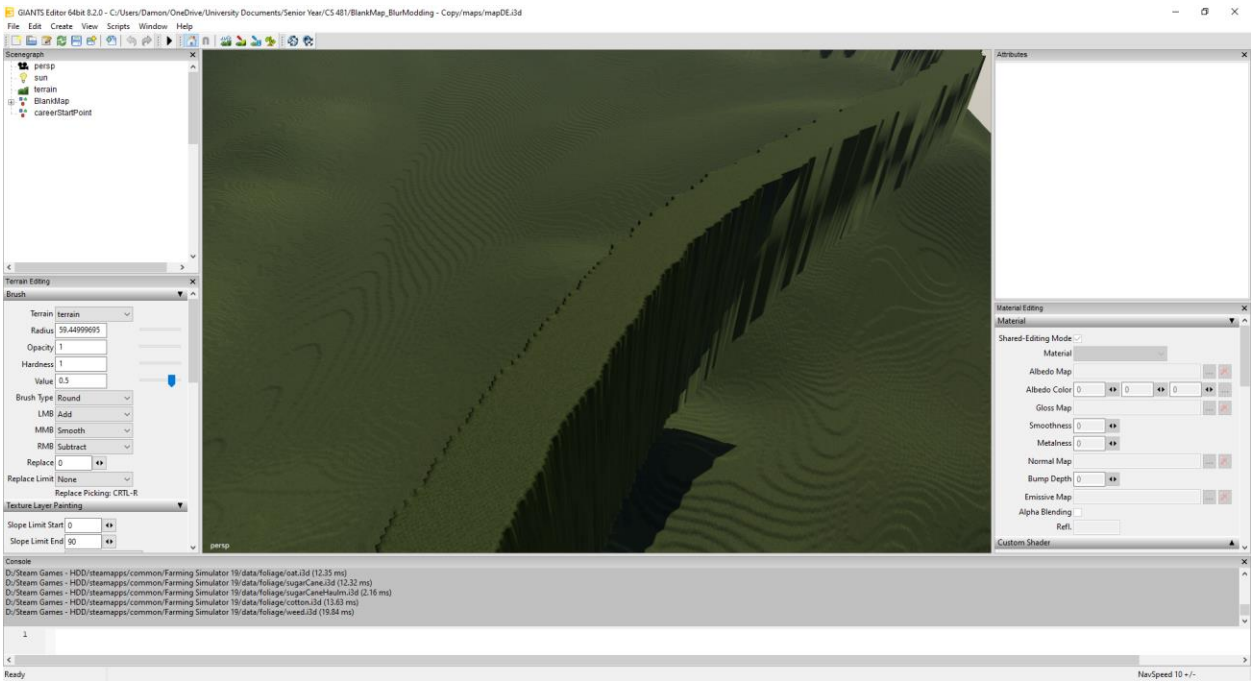
Nov. 17, 2020

Using the procedure from the previous entry, I continued with the GIMP file, and drew on top of the map DEM to show the correct placement of roads. This is shown below.

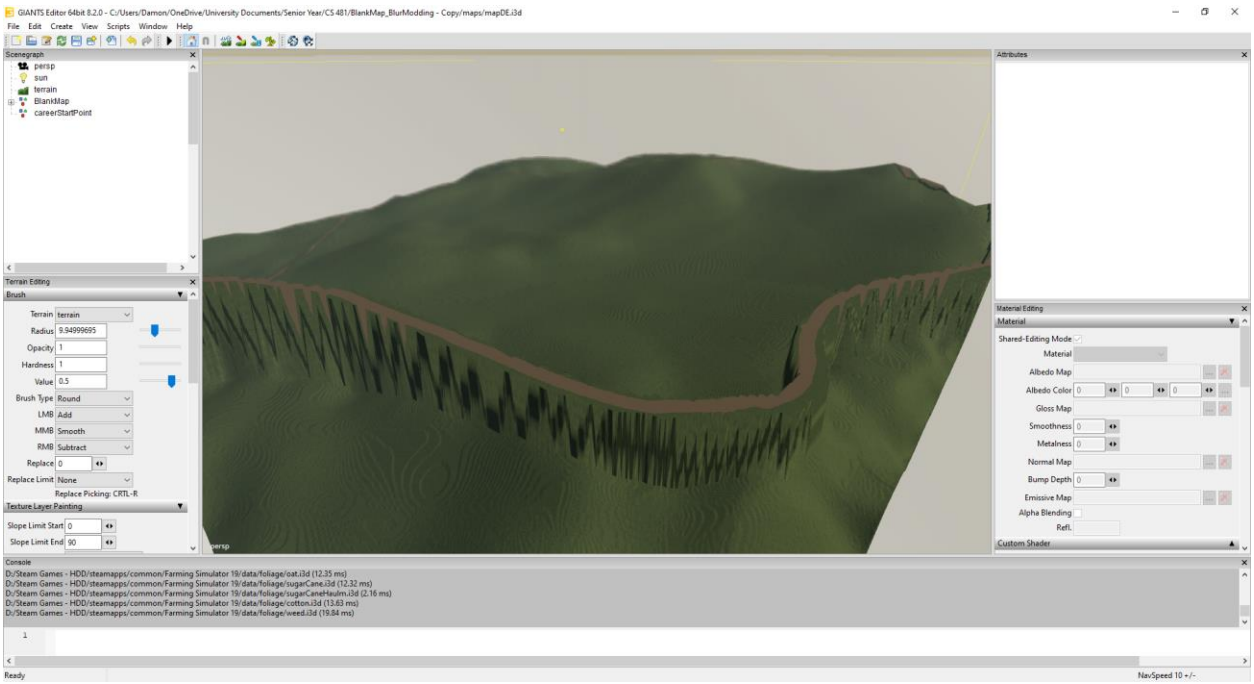


When this DEM is opened with GIANTS, the result is shown below.





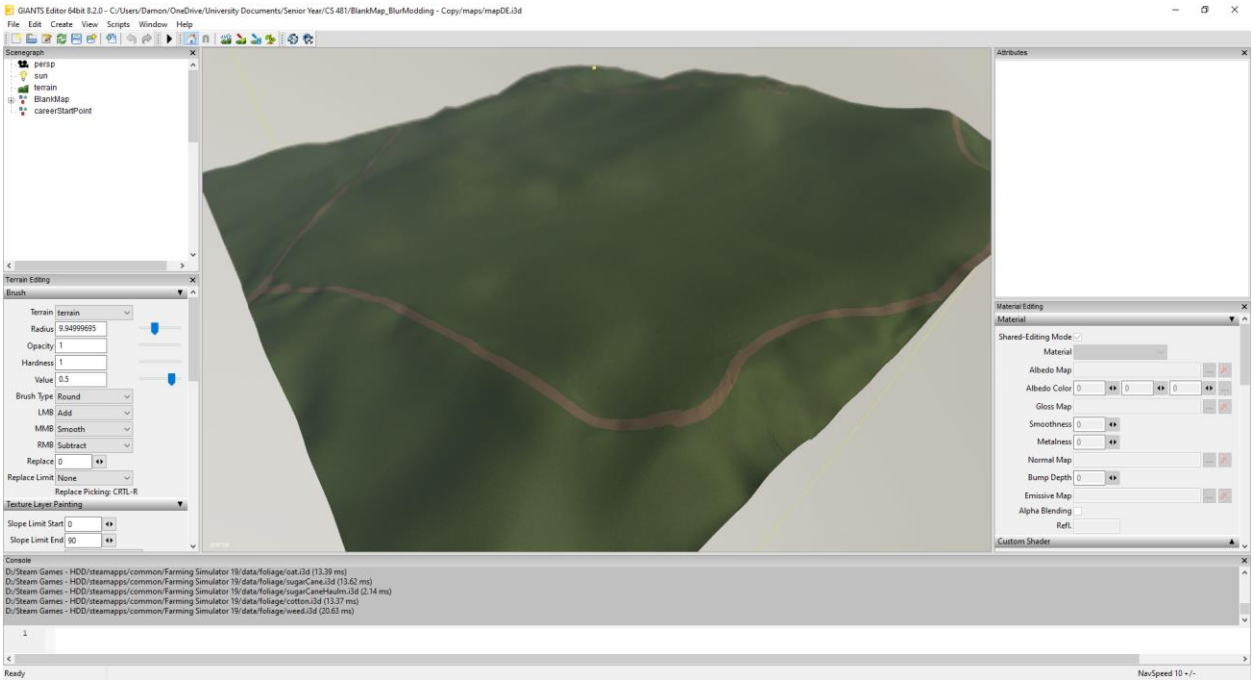
Note the high wall-like structure on the right side of the map. This is the white line we drew. It is intrpreted as the maximum elevation, which corrsponds to the white color. If we chose black to draw this, it would be at the lowest elevation possbile. Using this new wall as a guide, I painted the top of it with the gravel texture, which should be selected by default. After painting, the result is shown below.



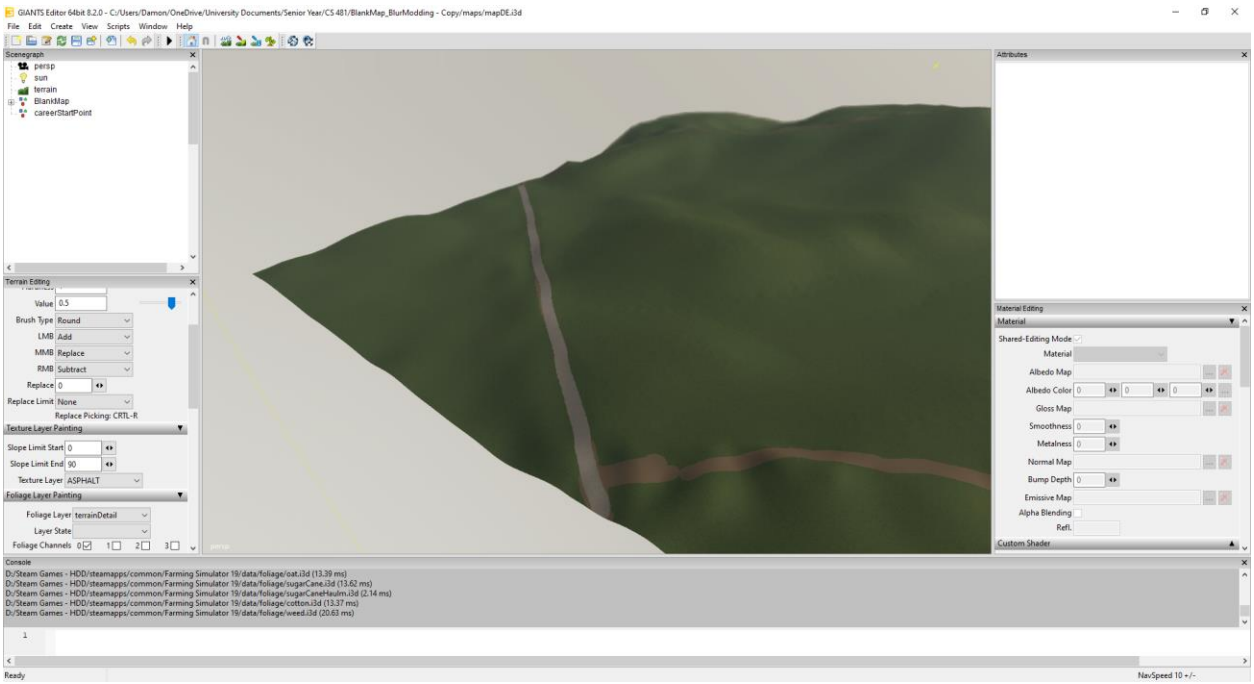
The reason why this works is because GIANTS uses different images to record placement of textures. These work almost as layers, and are all added on top of the base terrain to look correctly. After painting, the gravel layer image is shown below.

This image shows the placement of the gravel texture. White means the texture is present, black means it is not. Even if we change the DEM, this will still remain unchanged. Given this, we can revert the DEM to remove the high terrain which

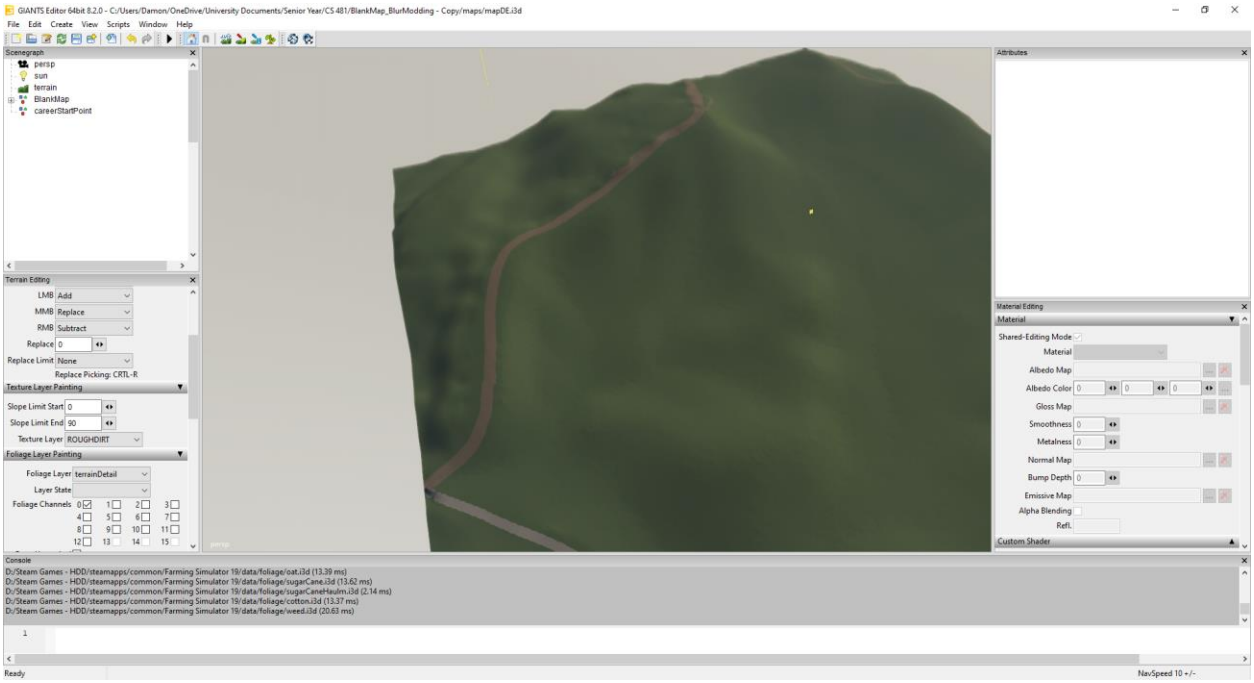
marks the roads, and reload GIANTS. Once complete, the result is as follows.



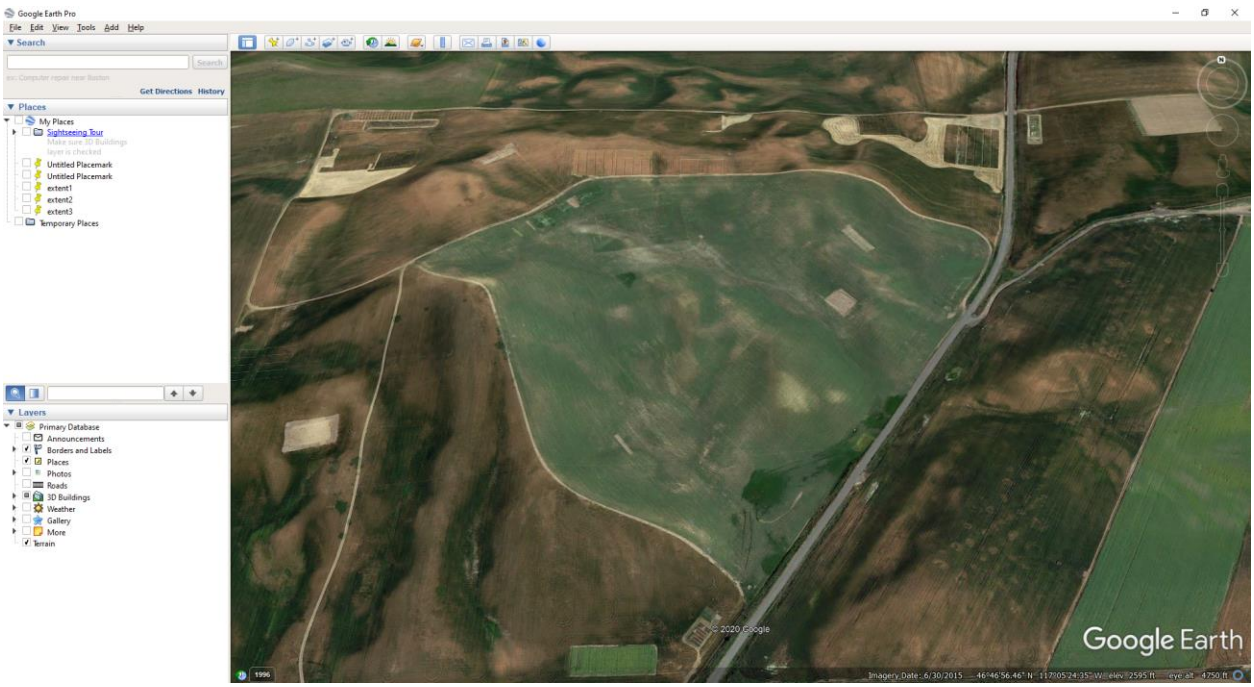
Given the actual nature of these roads, these markings are not that bad. The only actual road that exists as a paved road in the long straight road in the top left of the map, shown in the previous image. We need to mark the actual roads as pavement somehow. I did this and painted the paved roads with the ASPHALT texture.



I also repainted over some of the previous, rough lines to look a bit better.



At this point, we can then mark the place for buildings. We will mark these with concrete. Taking a look at google earth, which is my only reference for where to place buildings, we see the following.



As seen in the photo above, there simply are not any buildings in the extents of tha map. As a result, this step is not essential. Any additional steps at this point are cosmetic for the map.