Lab Report

Title: Lab 2-Part 1
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Project Repository: https://github.com/mmarsole/GIS5571
Google Drive Link: NA
Time Spent: 12hrs (?)

Abstract
This lab required us (students) to use our previous practice of building ETL's to download lidar data and PRISM data, and then construct python Notebooks that visualized the data via python code. From the lidar data I created a DEM and TIN files (both accessible in GitHub) and explored the various visualizations tools with ArcGIS Pro for lidar data (which has the capabilities for both 2d and 3d displays). After downloading the PRISM data, I converted it to Space Time cubes, and then made a GIF (also available on GitHub) to summarize the average monthly precipitation values for the continental US.

Problem Statement
Building ETL's to download lidar and PRISM data. Converting the data to relevant exploratory formats for analysis (lidar to DEM/TIN and PRISM to Space-Time cube/GIF).

Table 1. Information Represented in Data

#	Requirement	Defined As	(Spatial) Data	Attribute Data	Dataset	Preparation
1	Elevation data	Points returned to sensor (elevation extracted from time traveled)	Point (lidar) data	Intensity, class, ground point, etc.	MN DNR	Converted to a DEM/TIN
2	Precipitation data	Monthly average precipitation measures (over 30 years) for 4km cells over the continental US	raster	Precipitation value (measured in inches)	PRISM Climate Group	Converted to tif, added to mosaic, merged into a multidimensional layer then a Space time cube

Input Data
Las data, contains several additional attributes (intensity, classification, return, etc.). The area extant covers St. Paul MN, and can be used to create a DEM, DSM, and TIN model (which in turn can be used to make contour maps, slopes maps, or elevations). This one file contains

approximately 13,000 points but could be combined with other las files to broaden its spatial extant.
The PRISM data, encompasses the entire continental US, and has a cell raster size of 4km. This data summarizes precipitation over a given area over a span of 30 years for each month. Thus, through an analysis you should be able to detect seasonal precipitation changes over the year.

Table 2. Data Downloaded via ETL

#	Title	Purpose in Analysis	Link to Source
1	4342-12-05.las	Las file used to construct a DEM and TIN model	MN DNR
2	PRISM_ppt_30yr_normal_4kmM2_01_bil.zip (12 files for each month)	12 files were converted to a tif, and used to build a mosaic then used to make a Space Time Cube (basically rasters layered by time representing months)	PRISM Climate Group

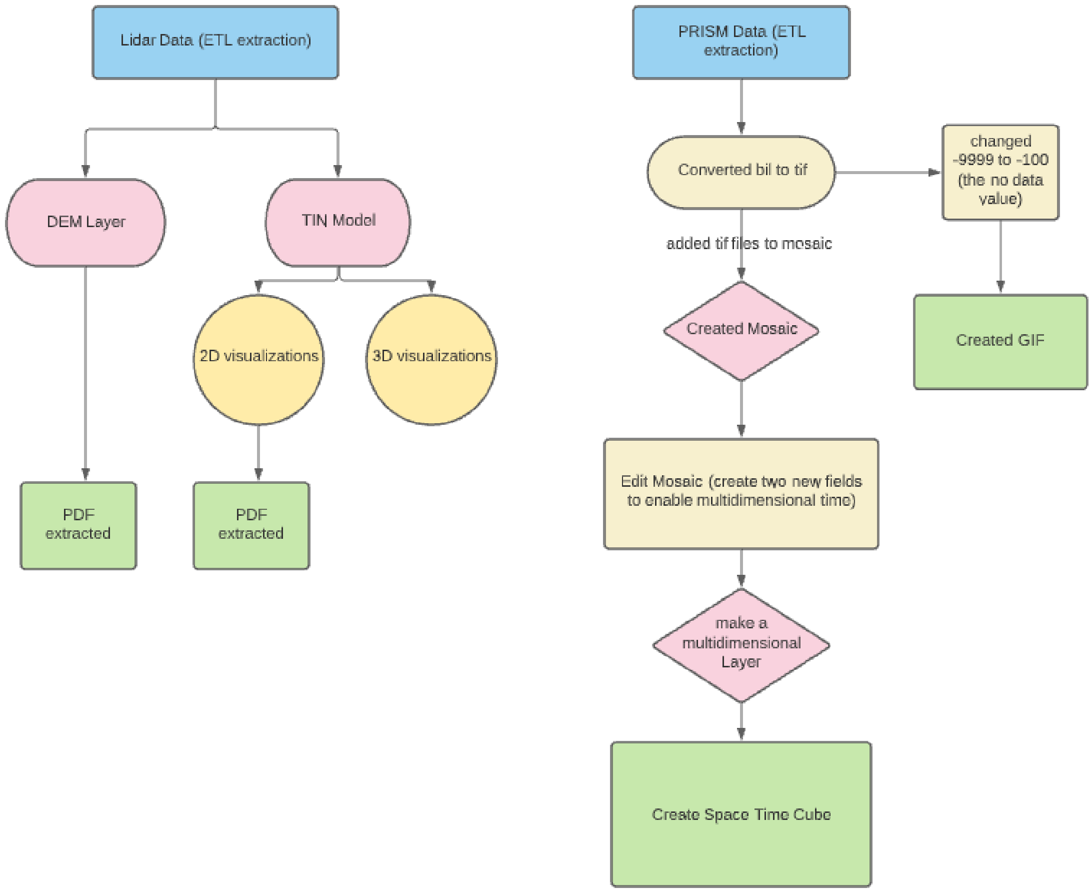
Methods

Two construct the DEM from the las data, I first had to convert it to a dataset (using the 'Create Las Dataset' tool), since Arcpro's Tool 'Las Dataset To Raster' will only convert a dataset to a DEM. Then using the dataset again and the 'Las Dataset To Tin' tool, I made a TIN network. The parameters I used to make my TIN network involved thinning my data up to 30% (I retained 70% of the original data) and had a maximum of 10,000,000 nodes, see figure 3 for a visual of the TIN. Because I didn't reduce the size of this TIN I couldn't successfully export a PDF for the actual TIN network (the submitted TIN pdf is an image of the elevation and contours made from the las dataset see Figure 2 instead of the actual TIN)

Creating the Space Time cube from the Prism data involved several steps. First I converted all the .bil files (12 , one for each month) to .tif files using 'Raster To Other Format' function. Then I created a Mosaic and added all .tif files to the mosaic. With this new mosaic I then two create two new fields ('variables') one populated with the precipitation values ('ppt') and the other to convey time (as months). Based on these new fields in the mosaic, I then used the 'Build Multidimensional Info' function to make a multidimensional layer, which was then used to make the Space Time cubes for precipitation (see figure 1 for this work flow).

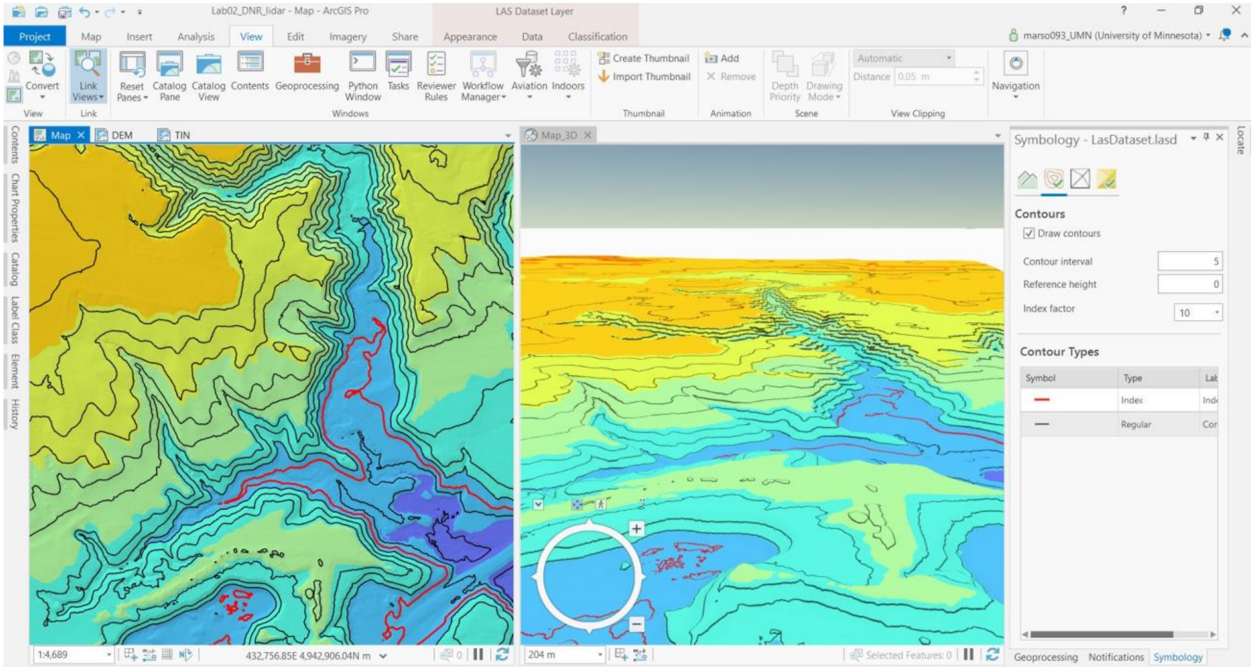
Making the Gif ('animation of the timeseries') began with the tiff files, which had to edited so that the 'no data' values (designated as -9999) were less extreme (-100). This step enabled us to distinguish the more subtle differences in precipitation values. The .tif files were then stacked with a designated fps (frames per second) and labeled with text to help distinguish each month's precipitation tif from one another.

Figure 1: Work process for Both lidar and PRISM outputs.



Although I didn't make a flow diagram for the visual comparison of 2D and 3D lidar data, I have provided an image to show the differences in viewing the lidar data in each respective view (the data was colored by elevation via contours).

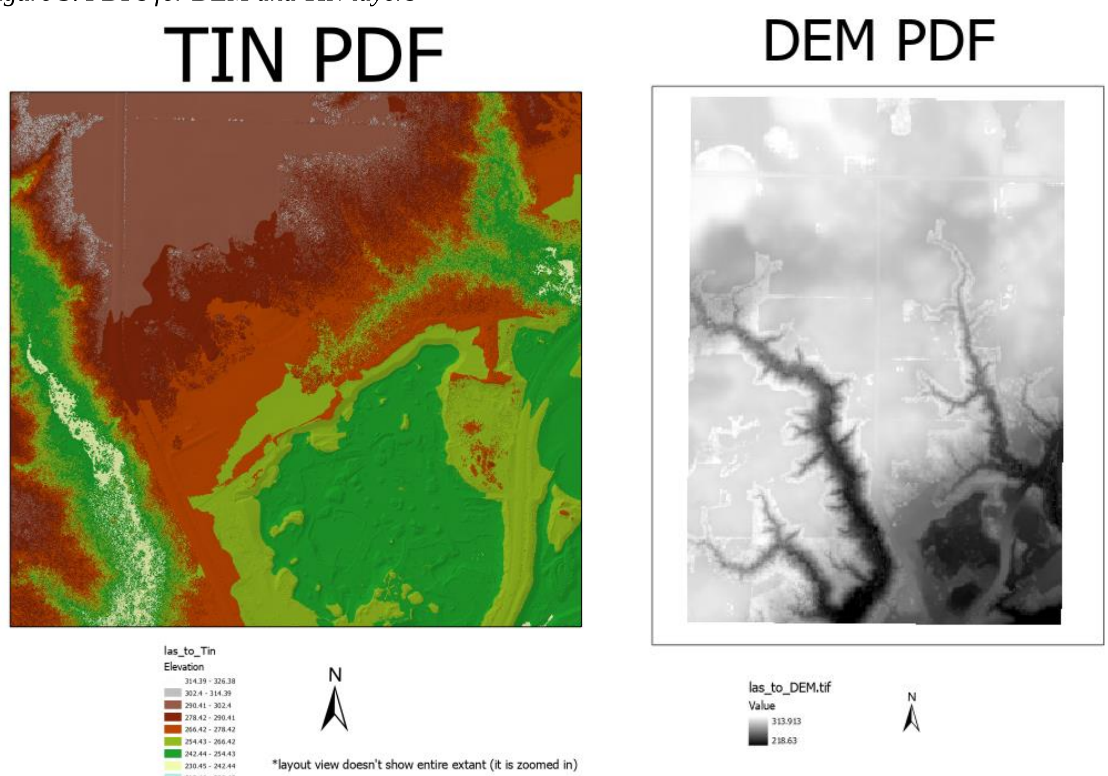
Figure 2: 2D and 3D visualizations of TIN models made from lidar.



Results

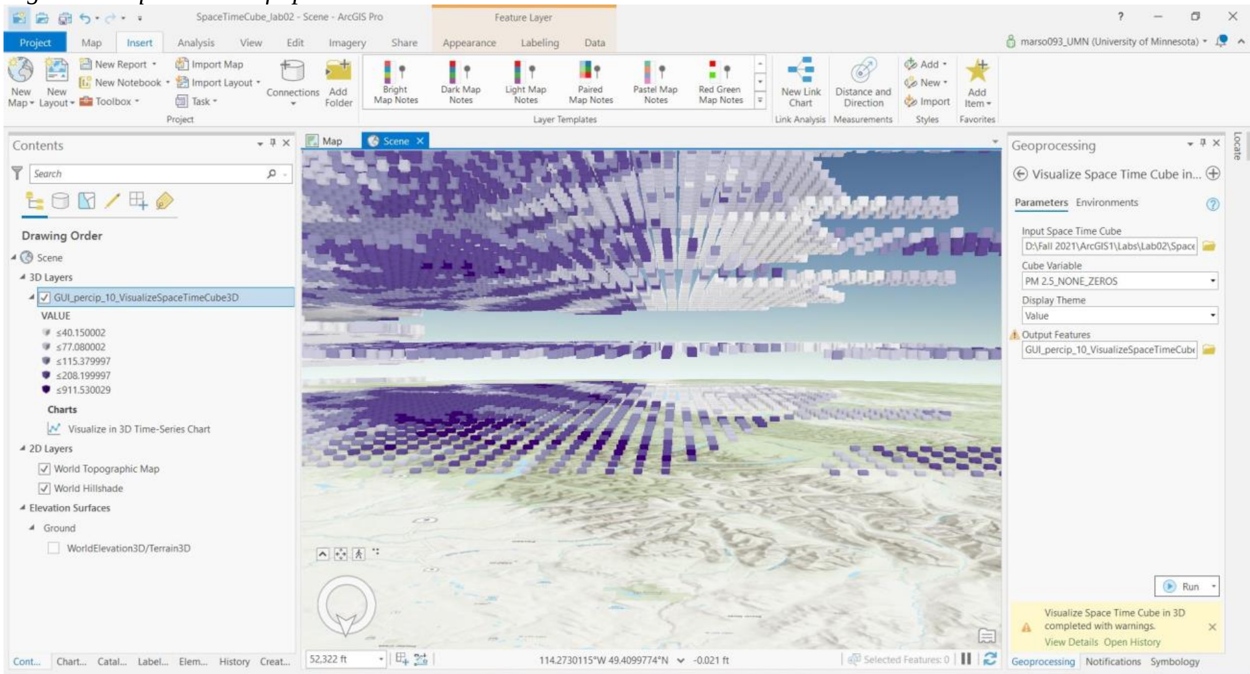
As mentioned previously, I have several results. In figure 3 you can see the PDF's extracted form ArcPro (one for the TIN network and the other for the DEM constructed from the lidar data). It should be noted that I extracted these PDF's via code, but had to make each pdf in the GUI interface first.

Figure 3. PDFs for DEM and TIN layers



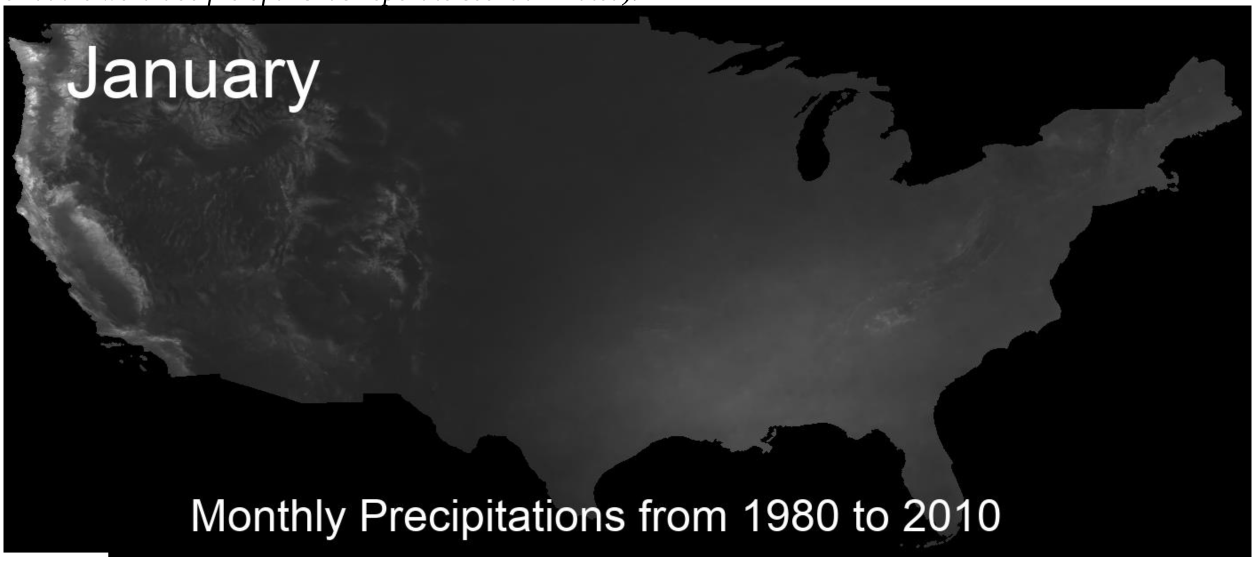
Secondly, I made Space Time cubes of the precipitation data (Prism). In figure 4 you can see a still image of the cubes stacked in layers (each layer represents a corresponding month's precipitation). This step in visualizing the data was slow (due to the size of the data, which was the continental US), and not very reliable since it took minutes for the screen to populate the visual data.

Figure 4. A quick view of Space Time Cubes in ArcPro



Lastly, in figure 5 you can see the resulting Gif made for the Prism data. This gif was constructed outside of ArcPro (but still within Jupyter notebooks) with the use of 'imageio' package.

Figure 5. GIF of precipitation data. (won't see animated image in pdf, please look at the Gif file provided in GIthub or at the word doc file of this lab report to see it animated).



Results Verification

I was able verify the monthly raster images produced in the gif, by visually inspecting the raster files within the ArcPro interface (the visuals were slightly different due to ArcPro's utilization of stretching raster values such as 'Percent Clip'). This corroboration confirmed my GIF output. The Space Time cube was harder to corroborate, since I couldn't easily inspect the output visually (the data often crashed the computer or took a very long time to load).

The DEM and TIN models produced from the lidar data corroborated each other visually (the elevation data was comparable, although each type of layer emphasized different geological features).

Discussion and Conclusion

I have never used or visualized Space Time cubes before this assignment and was interested in why we go through the effort. It seems to me visualizing space time cube may not be worth it (given the loading time and the resulting view) since it is hard to discern any easy pattern with my inspection. I think this method is helpful, if I were to try to perform some sort of analysis with in it but as a visual it is limited (or maybe it'd be better to inspect a smaller extant). On the other hand, the 3D view for the contour data, was helpful. It provides the viewer the opportunity to change their viewing angle to inspect the terrain.

Overall, if I were to improve the work in this lab, I would try to create the space time cubes with a smaller exatne so that could inspect the result.

References

Buie, L. (2020, February 11). Explore your raster data with Space Time Pattern Mining. ArcGIS Blog. https://www.esri.com/arcgis-blog/products/arcgis-pro/analytics/explore-your-raster-data-with-space-time-pattern-mining/

*GIF making code was based upon my past assignments in from Intro to Geocomputing

Self-score

Category	Description	Points Possible	Score
Structural Elements	All elements of a lab report are included **(2 points each)**: Title, Notice: Dr. Bryan Runck, Author, Project Repository, Date, Abstract, Problem Statement, Input Data w/ tables, Methods w/ Data, Flow Diagrams, Results, Results Verification, Discussion and Conclusion, References in common format, Self-score	28	28
Clarity of Content	Each element above is executed at a professional level so that someone can understand the goal, data, methods, results, and their validity and implications in a 5 minute reading at a cursory-level, and in a 30 minute meeting at a deep level **(12 points)**. There is a clear connection from data to results to discussion and conclusion **(12 points)**.	24	22
Reproducibility	Results are completely reproducible by someone with basic GIS training. There is no ambiguity in data flow or rationale for data operations. Every step is documented and justified.	28	26
Verification	Results are correct in that they have been verified in comparison to some standard. The standard is clearly stated **(10 points)**, the method of comparison is clearly stated **(5 points)**, and the result of verification is clearly stated **(5 points)**.	20	18
		100	94