A Decade Later: the Lasting Impact of the 2013 Flood

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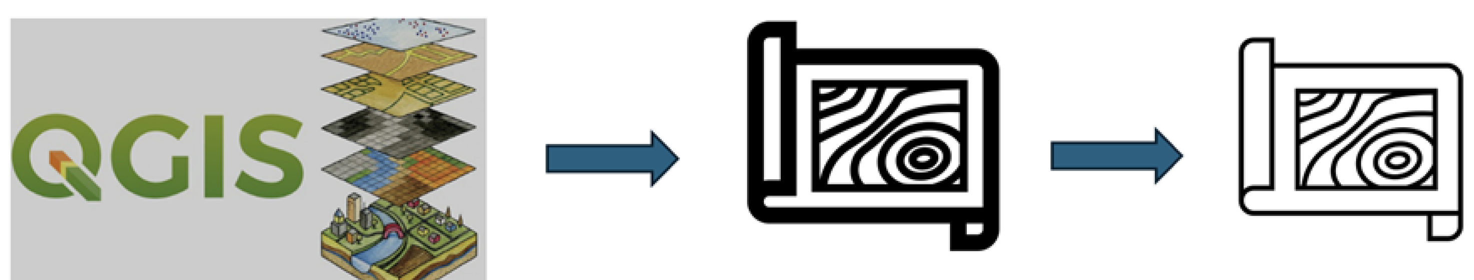
Introduction/Background

In September 2013, a severe rainstorm event along the Front Range of Colorado causing flooding, debris flows, and landslides, particularly impacting the area between Estes Park and Boulder. The storm had a massive impact on both humans and other organisms—roads and houses were destroyed, and the landscape was instantaneously changed. While we have repaired much of the infrastructure that was damaged, it remains unclear where sediment from the flooding, debris flows, and landslides is today. This project aims to determine how changed the 2013 Flood deposits are compared to immediately after the flood. In other words, has the sediment moved in the decade after the storm? By looking at the debris flow deposits from a 2015 study of the area, data analysis from before and after the event was analyzed using a GIS system. This data helps researchers since this is not the first storm that has caused landsliding and debris flows in the Front Range (Godt & Coe, 2007). It is necessary to understand the decadal impacts of these types of storms and their consequences because as climate change is exacerbating the chance of a landslide happening in the western US increases (McGuire et al. 2016).

The event and its slides: Between September 9 through the 13 of 2013, more than 1,238 debris flows in a 3,430-km^2 area of the Colorado Front Range (N 40.0°–40.375° and W 105.25°–105.625°) (Baum et al. 2016) were triggered after ~75 mm of antecedent rain (Coe et al. 2014) (Schaefer et al. 2021).

Methods



Imported all data into QGIS including DEMs & lidar → Clipped data to sample area → Raster calculator used to differentiate mapped areas

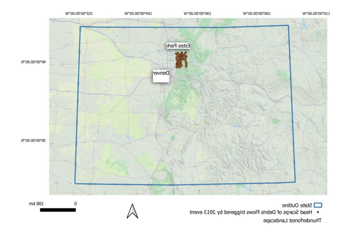
This project is using remote sensing methods. This includes collecting, merging, and comparing lidar & digital elevation models (DEMs) from different years.

1. All the data was imported into QGIS using the NAD83 UTM Zone 13N coordinate system.
2. Clipped the USGS DEM image of the northwestern area of the Front Range to the 2021 DRCOG data. (U.S. Geological Survey, 2023).
3. Clipped the 2021 DRCOG data to the sample area (U.S. Geological Survey 2021).
4. Clipped the 2013 flood data to the sample area (Baum et al., 2016).
5. Clipped the 2010 Boulder determine data to the sample area. ((National Center for Airborne Laser Mapping (NCALM) & Boulder Creek Critical Zone Observatory (CZO, 2010).
6. Used the raster calculator to differentiate the 2013 DEM from Baum against the 2023 DEM. Both DEMs are from the National Map database.
7. Used the raster calculator to differentiate the 2013 Flood lidar data from the 2010 Boulder Creek lidar data.
8. Used the raster calculator to differentiate the 2013 Flood lidar data from the 2021 DRCOG lidar data.

Figure A:

Area Map

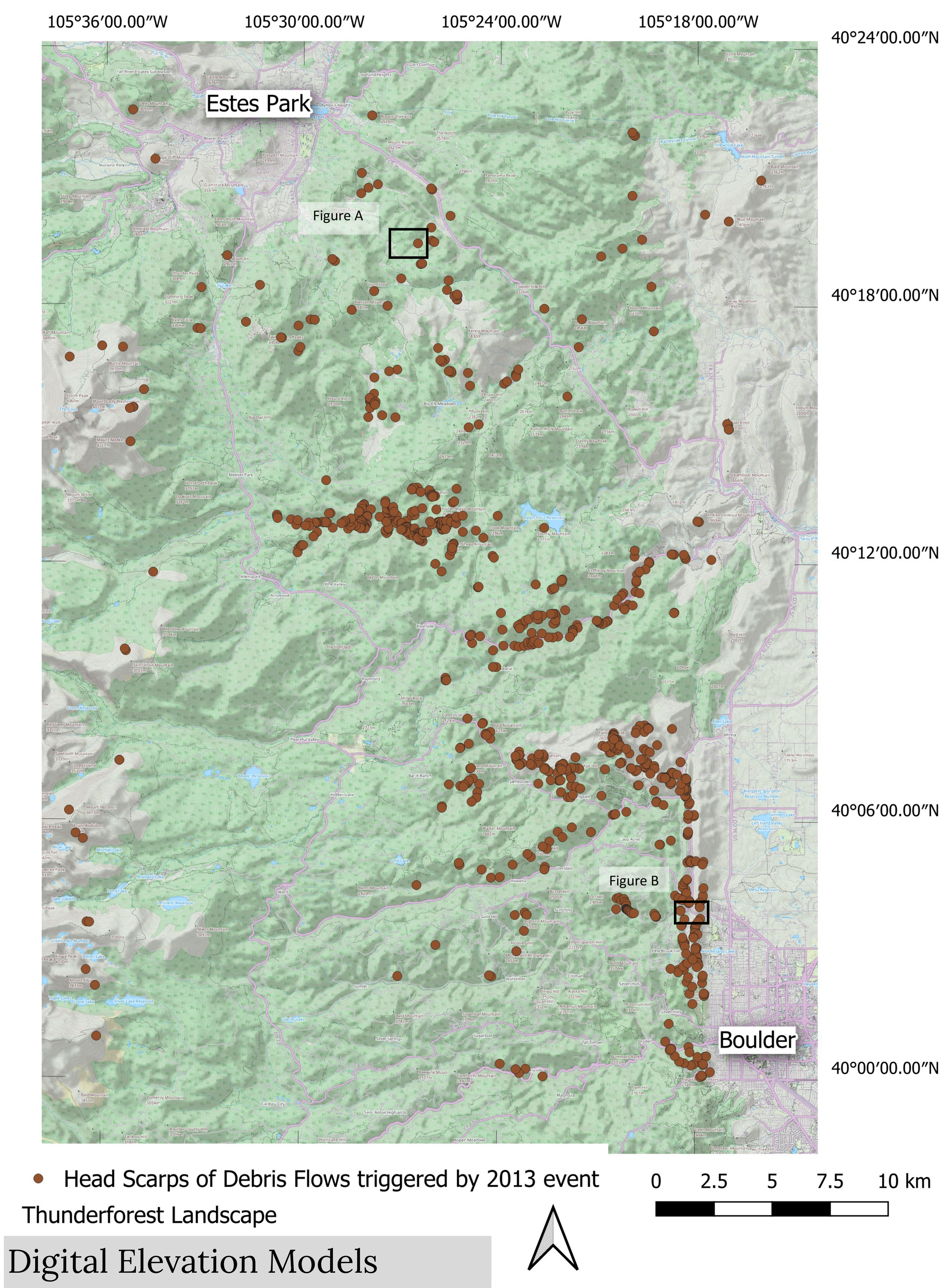
Overview of the Study Area



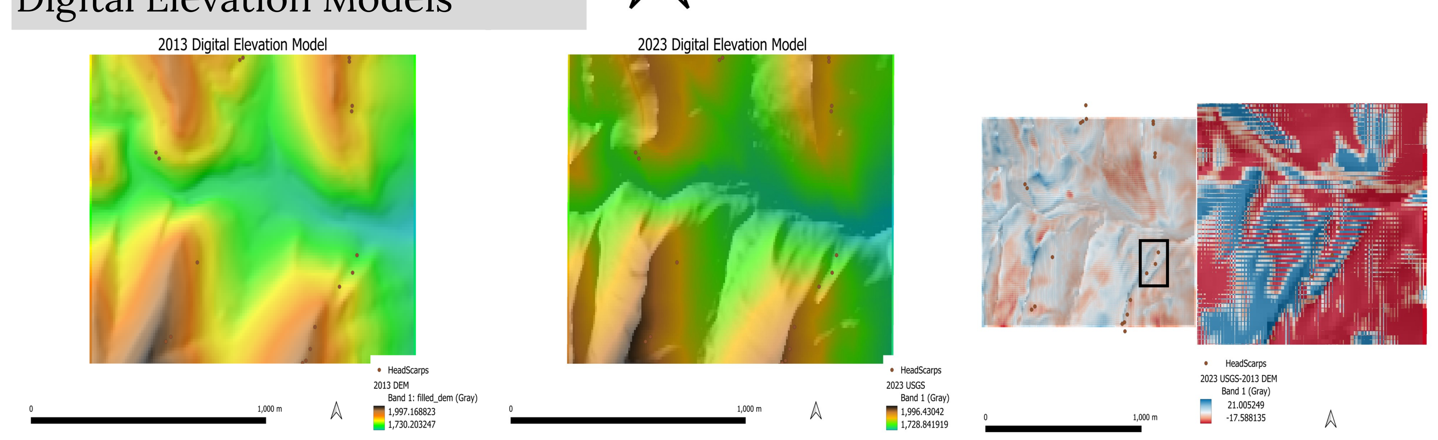
The basemap is a Thunderforest Landscape map.

The dots are the head scarps that were surveyed by Coe et al. in 2014.

The data comes from the supplemental information from Coe et al., 2014



Digital Elevation Models



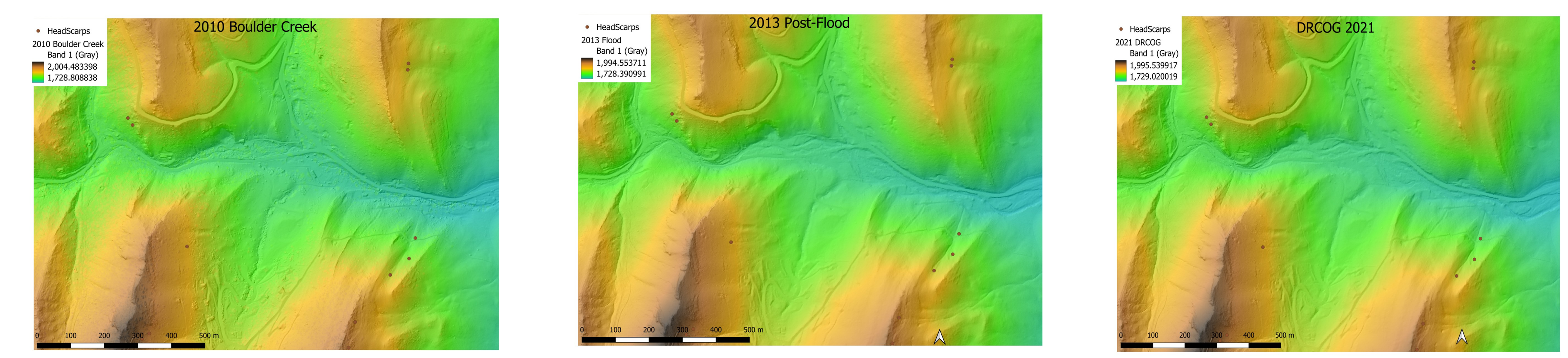
I took the Digital Elevation Models (DEMs) from 2013 and 2023 and placed them under their respective hillshades. I used the raster calculator to subtract the 2023 DEM from the 2013 DEM to create a difference map.

Data	Acquisition Time	Spatial Resolution	Downloaded Resolution	Data Source
Baum Map Model	9/9/13—9/13/13			U.S. Geological Survey, NORTHWEST REGION (Baum et al., 2019)
Boulder Creek Critical Zone Observatory August 2010 LiDAR Survey	8/21/10 - 8/26/10	1 meter	1 meter	National Center for Airborne Laser Mapping (NCALM) project and the Boulder Creek Critical Zone Observatory (CZO)
CO Cameron Peak Fire	9/7/21 - 9/22/21	5.86 pts/m^2	1 meter	Sanborn Map Company
CO DRCOG 3 2020		11.78 pts/m^2	1 meter	Sanborn Map Company
CO DRCOG 2 2020		11.78 pts/m^2	1 meter	Sanborn Map Company
CO DRCOG 1 2020		11.78 pts/m^2	1 meter	Sanborn Map Company
2013 South Platte River and Denver Post Flood	10/16/13 - 7/22/14	3 centimeters	3 centimeter	Compass Data Inc.
USGS Raster	3/14/2023	1/3 arc second	7.9 meters	National Map

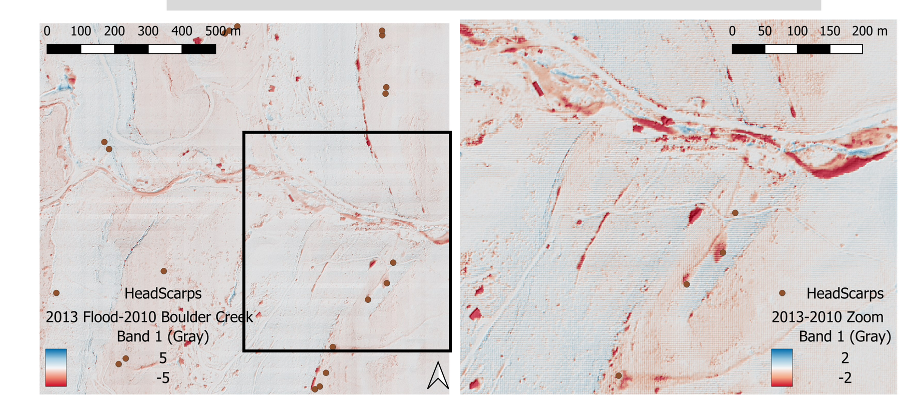
Results

- The results were created for the different years by taking the maps and symbolizing with a color bar the differences between the high and low elevations.
- The difference maps were done by subtracting the pre and post flood images from the after flood images and creating a color bar showing the differences in pixels between the pre and post flood maps.

Figure B:

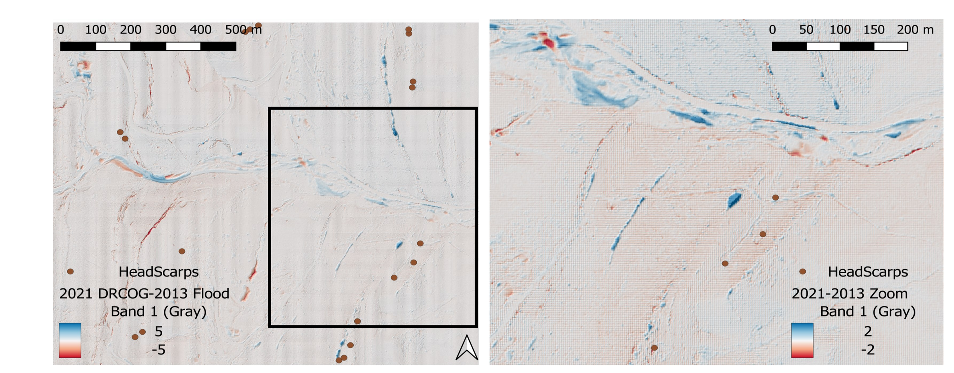


Before and After the Flood



I took the Lidar images from 2013 and 2010 and placed them under their respective hillshades. I used the raster calculator to subtract the 2013 image from the 2010 image to create a difference map.

10 Years Later



I took the Lidar images from 2013 and 2021 and placed them under their respective hillshades.. I used the raster calculator to subtract the 2021 image from the 2013 image to create a difference map.

Discussion/Conclusions

The small study area of my project was an area outside of Boulder; Four Mile Canyon Creek.

Between 2010 and 2013, the flood caused a lot of changes to the area. The flood caused a lot of debris flows in the area.

From 2013 to 2021, there has been very little change to the area of the flood. Instead, the changes have happened to the area due to human developments (roads, buildings). The river changed its flow due to the debris. Rivers meander and change where they flow over time as seen in the Lidar images.

The issues with the Digital Elevation model (DEM) data is that the U.S. Geological Survey does not store old DEMs for more than a year on the National Map. I do not have the unedited DEM from 2013. The DEM is labeled as "filled_DEM" so I can infer that it has been edited. The DEMs and Lidar data have issues due to the aerial object that was flown over the area may not have taken the same route in the dates that I wanted. Finding the relevant data was not an easy task as all the data that I wanted did not exist. I had to find data that was close and clip it to the study area.

I will be continuing at Front Range Community College to earn my Bachelor of Applied Sciences in Geospatial Science.

Acknowledgements

I would like to thank Greg Tucker and his Community Surface Dynamics Modeling System group meetings for giving me feedback on my work. I would like to thank Alicia Christensen and Karla Lemus for their work with the Research Experience for Community College Students conducting lectures and showing us how to stay ahead of getting our work done. I would like to thank Amy Dunbar-Wallis for giving me feedback on each of the parts of my poster.

References: