Exploration of Structure from Motion Programs and their Application to Improving Student Learning in Geoscience Classrooms

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Abstract

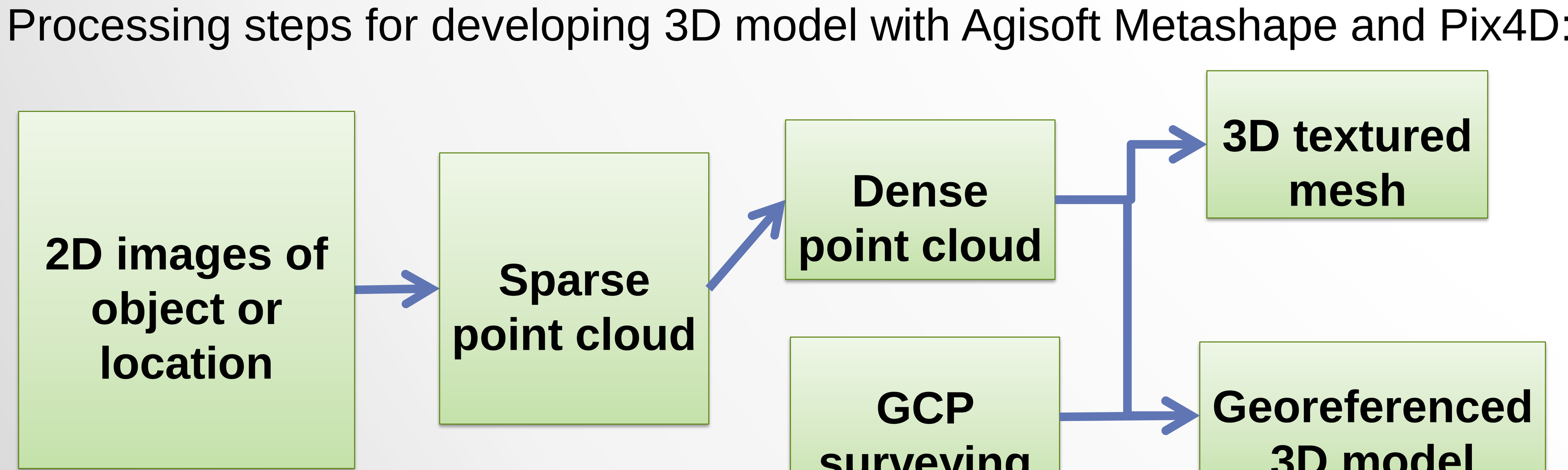
Advancements in remote sensing methods within the last decade have dramatically improved the quality and accuracy of geoscience research. However, there is much potential to be explored in how these methods can improve the student experience in geoscience education. Remote sensing encompasses the use of technology such as Unmanned Aerial Vehicles (UAVs), GPS measurements, and photogrammetry programs such as Structure from Motion (SfM) to record observations and document changes in the Earth from a distance. The purpose of this project is to develop approaches that provide students in geoscience courses experience with data collection, analysis, and interpretation skills. Several SfM programs, such as Agisoft Metashape, Pix4D, and Regard 3D were experimented with to create 3D models from 2D images of objects and field sites. Fully rendered 3D models of inanimate objects, landscapes, and geologic outcrops were created to determine the workflow and best practices for later creating a cache of models for research and educational purposes. Agisoft Metashape was best suited for developing 3D models of objects, landscapes, and geologic outcrops, whereas Pix4D proved satisfactory for developing models that are georeferenced to a precise location on Earth. CloudCompare was evaluated for use in analyzing locations at different points in time or before and after significant geologic events for changes in volume or shape. CloudCompare will also be applied to the process of modeling selected rock samples due to its ability to remove extraneous features from models. These findings will guide the development of lesson plans designed to help students cultivate skills to work with remote sensing methods and data. These findings will also assist in the creation of virtual field trips in which students will be able to navigate through virtual representations of real field sites.

Purpose

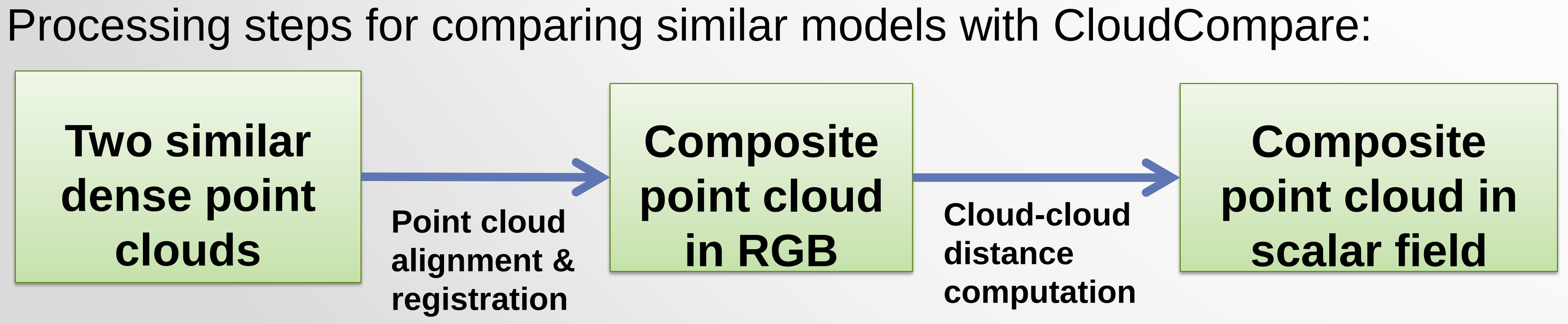
The purpose of this project is to adapt technological advances made in the field of remote sensing to improve the quality of student learning in geoscience classrooms (Anderson, 2019; Fombuena, 2017; Westoby, 2012). Through an analysis of Structure from Motion programs and their handling, we hope to determine optimal procedures for using these programs to build a cache of models for research and education needs.

Materials and Methods

Processing steps for developing 3D model with Agisoft Metashape and Pix4D:



Processing steps for comparing similar models with CloudCompare:



Results

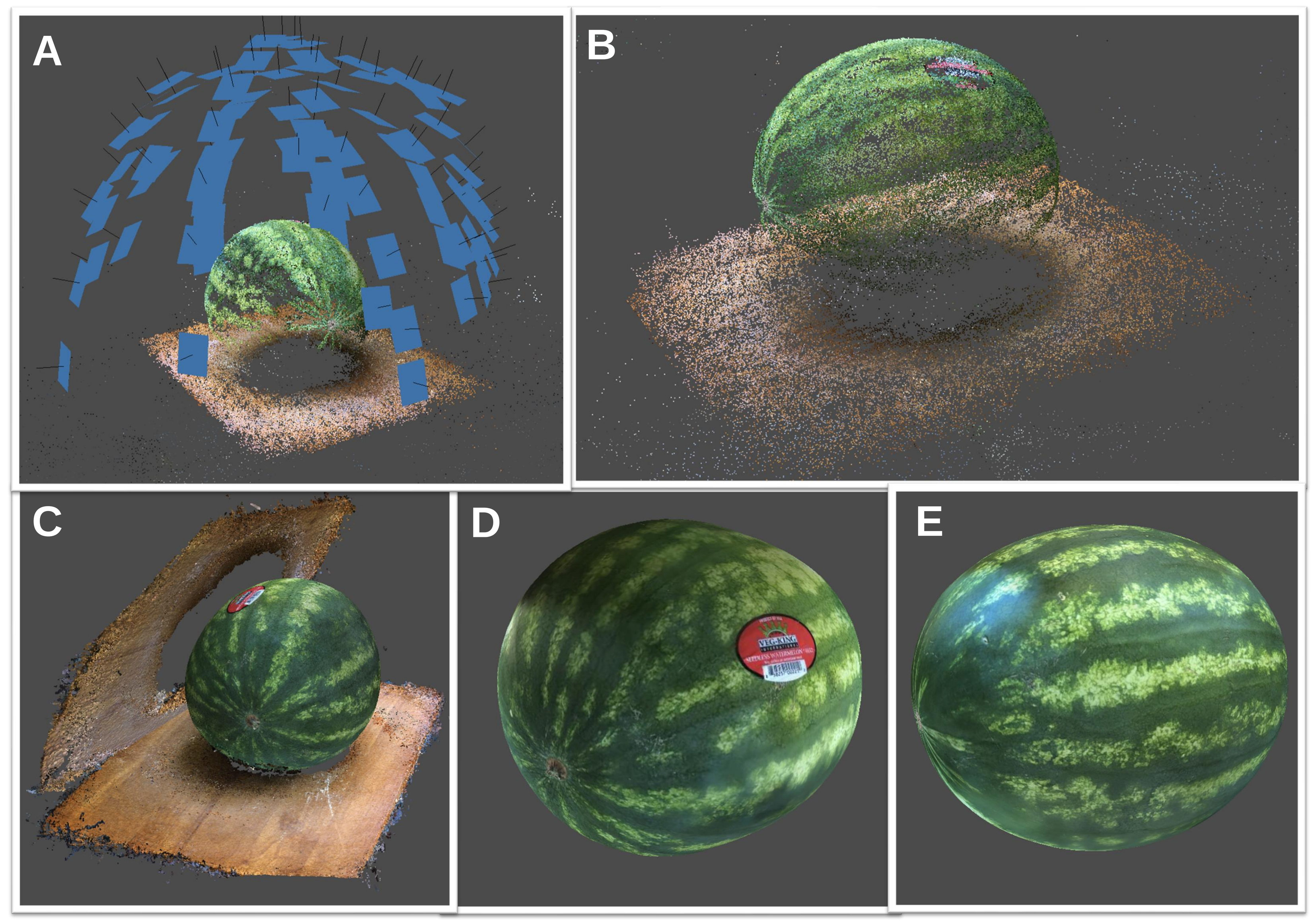


Figure 1. **Agisoft Metashape**. Shown above are various phases in the process of developing the 3D model of an object and isolating it from its background. (**A**,**B**) Sparse point cloud with and without camera positions (**C**) Merged dense point cloud (**D**, **E**) 3D textured mesh of watermelon isolated from background

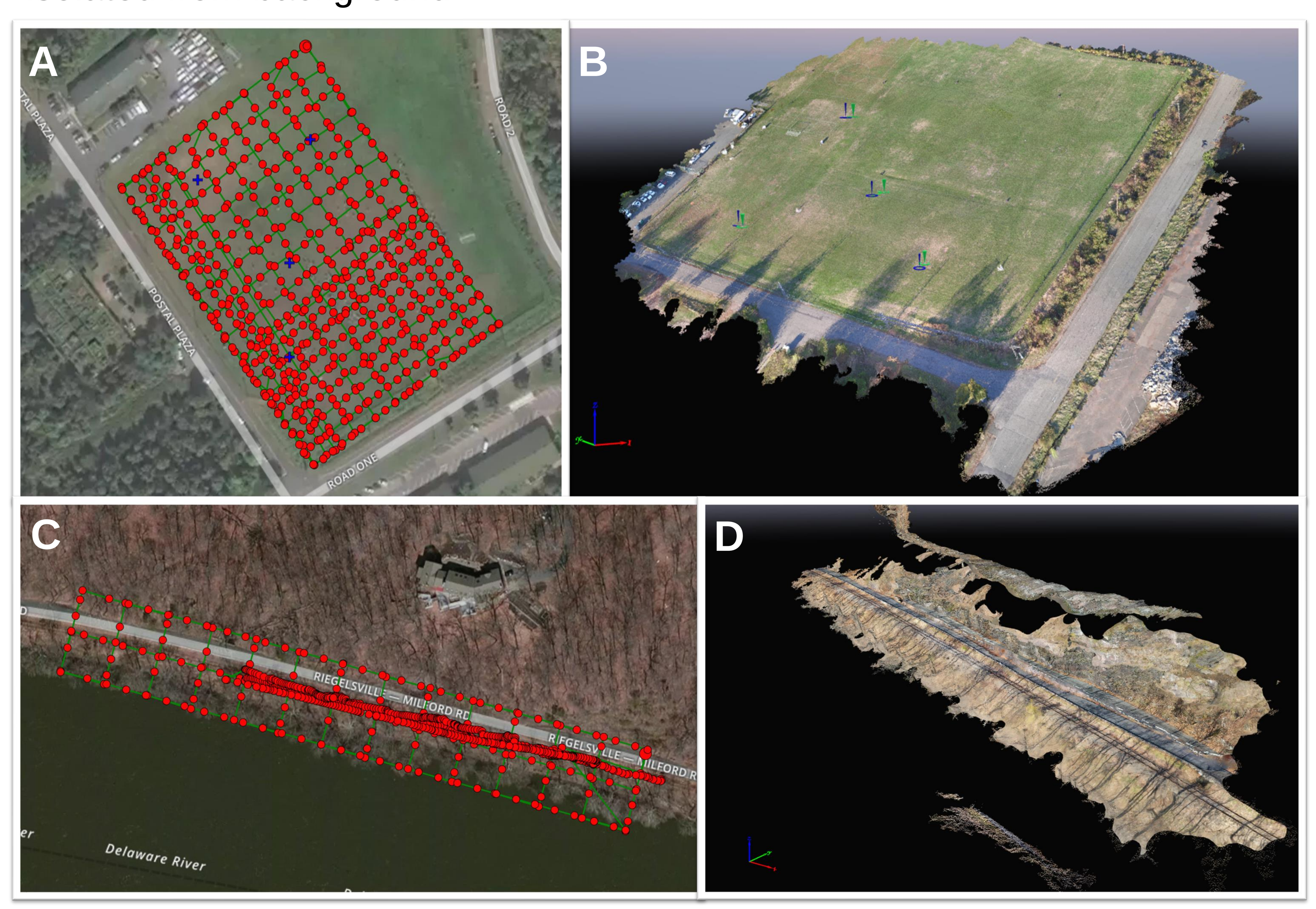


Figure 2. **Pix4D**. Shown above are the map views and 3D meshes for a soccer field (**A, B**) and the geologic outcrop of Pebble Bluff (**C, D**) imaged by the team's UAV, a DJI Mavic 2 Pro. The camera positions for each photograph taken by the UAV are represented by the red dots on the map view, while the GCPs for the soccer field are represented by the blue crosses on the map view and by the blue markers on the mesh. Processing issues occurred in the creation of the Pebble Bluff mesh (**D**) due to the misalignment of several portions of the model.

Results

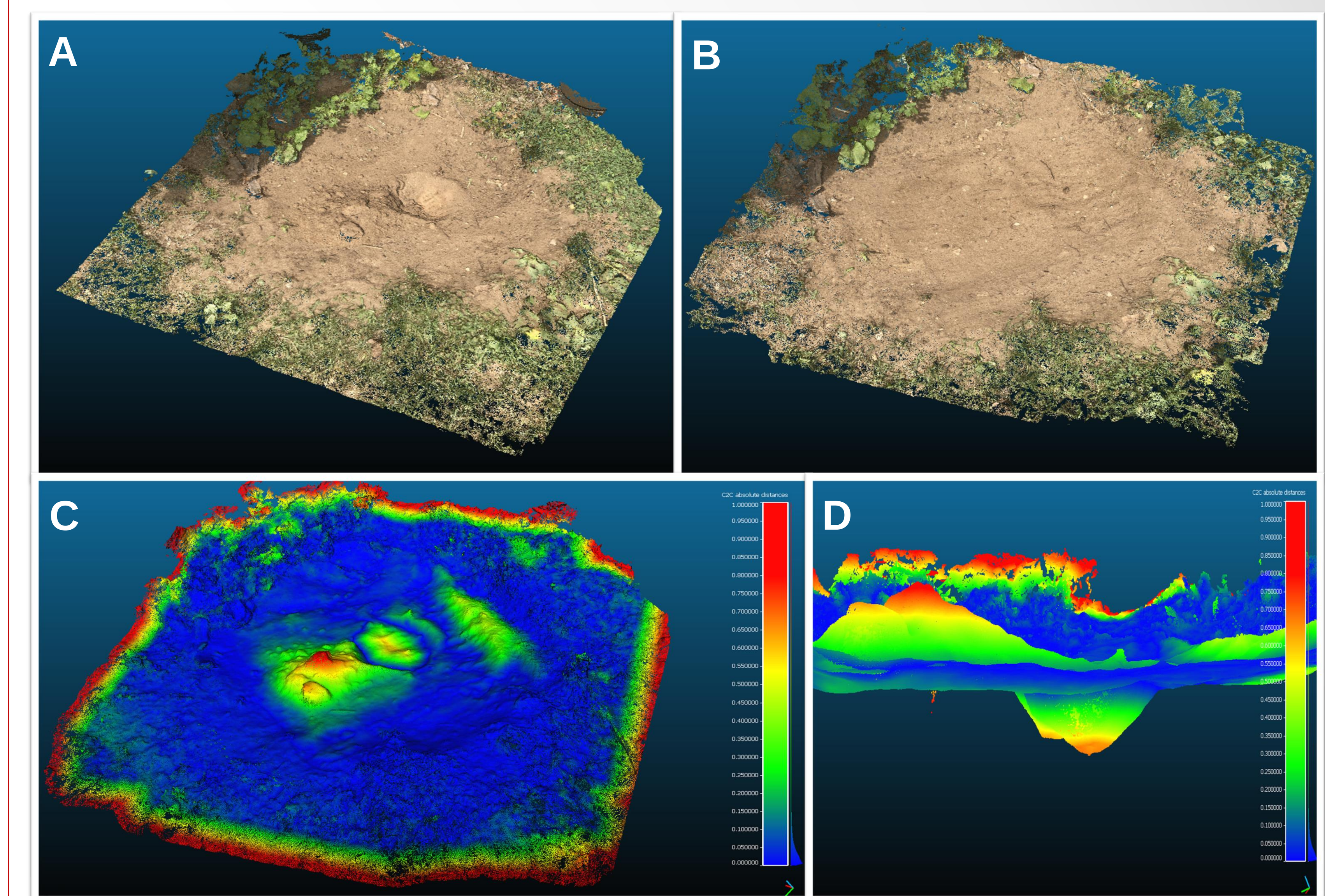


Figure 3. **CloudCompare**. Shown above are the point clouds of a dirt patch before (**A**) and after (**B**) leveling out the ground. The point clouds were aligned and registered together, then the cloud-cloud distances were computed and are displayed by the point clouds' scalar fields (**C**). Red>Yellow>Green>Blue represents the scale for decreasing distance between points matched in each point cloud, and a close-up side view of the model (**D**) shows changes in the scalar field between different elevations.

Preliminary Conclusions and Future Work

Evaluations of SfM programs:

- Agisoft Metashape: most appropriate for general use in developing 3D models of both objects and geologic outcrops.
- Pix4D: necessary in order to georeference models of landscapes and geologic outcrops, yet many processing issues were experienced.
- CloudCompare: provides ability to examine differences in shape and volume between models of geologic locations at different points in time.

Areas of Future Work:

- Use drone imaging at select field sites to collect remote sensing data that students will analyze and interpret in geoscience courses
- Develop a virtual field trip in which students will have access to a full 360˚ camera layout of a field site

Acknowledgments

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References

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