3D mapping: SfM model with LIME

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VOG

http://virtualoutcrop.com/lime

Data collected by J Ramón Arrowsmith

Tutorial notes

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OpenTopography
High-Resolution Topography Data and Tools

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Software Contribution

GEOSPHERE

GEOSPHERE, v. 15, no. 1

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9 figures

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LIME: Software for 3-D visualization, interpretation, and communication of virtual geoscience models

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ABSTRACT

The use of three-dimensional (3-D), photo-textured representations of topography from laser scanning and photogrammetry is becoming increasingly common across the geosciences. This rapid adoption is driven by recent innovations in acquisition hardware, software automation, and sensor platforms, including unmanned aerial vehicles. In addition, fusion of surface geometry with imaging sensors, such as multispectral, hyperspectral, thermal, and ground-based radar, and geophysical methods creates complex and visual data sets that provide a fundamental spatial framework to address open geoscience research questions.

Despite the current ease of acquiring and processing 3-D photo-textured models, the accessibility of tools for analyzing and presenting data remains problematic, characterized by steep learning curves and custom solutions for individual geoscience applications. Interpretation and measurement is essential for quantitative analysis of 3-D data sets, and qualitative methods are valuable for presentation purposes, for planning, and in education. This contribution presents LIME, a lightweight and high-performance 3-D software for interpreting and co-visualizing 3-D models and related image data. The software allows measurement and interpretation via digitizing in the 3-D scene. In addition, it features novel data integration and visualization of 3-D topography with image sources such as logs and interpretation panels, supplementary wavelength imagery, geophysical data sets, and georeferenced maps and images. High-quality visual output can be generated for dissemination to aid researchers with communication of their results. The motivation and an overview of the software are described, illustrated by example usage scenarios from outcrop geology, multi-sensor data fusion, and geophysical-geospatial data integration.

INTRODUCTION

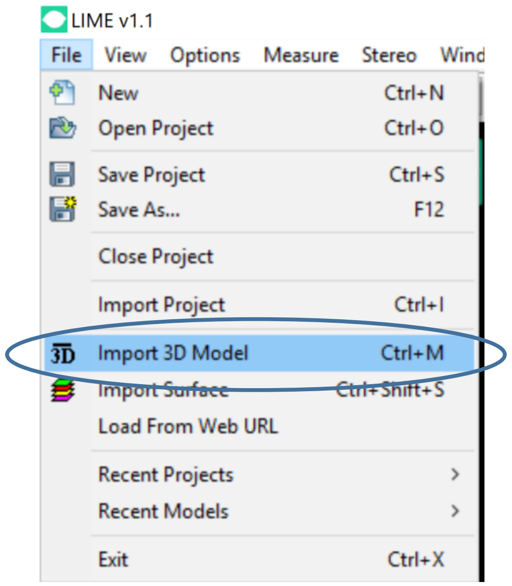
The use of digital spatial data is becoming commonplace in many areas of the geosciences (for example in geology, geomorphology, cryospheric science, volcanology, natural hazards, hydrology, energy, infrastructure, and mining). Laser scanning (lidar), global navigation satellite systems (GNSS), digital photogrammetry (also referred to as structure from motion [SfM]), and imaging remote sensing have all evolved heavily over the last two decades, and are distinguished by unprecedented resolution, precision, and ease of use. Computing hardware has developed to facilitate field-based acquisition (Weng et al., 2012; Kehl et al., 2017), and more analysis tools are available in geographical information systems (GIS). The evolving state of the art can be followed through the scientific literature, from early adoption to the status quo. This is exemplified by rapid adoption across the many arms of the geoscience subdisciplines (see, e.g., McCaffrey et al. [2005], Pringle et al. [2006], Buckley et al. [2008a], Kääb [2008], Pavlis et al. [2010], Jaboyedoff et al. [2012], Hodgetts [2013], Bemis et al. [2014], Eitel et al. [2016], Eltner et al. [2016], Kehl et al. [2017], and Squelch [2017] as a small subset of papers providing snapshots of developments through time).

The reinvention of photogrammetry—a technique that has advanced in line with photographic innovations—has recently intensified the adoption of three-dimensional (3-D) spatial data by geoscientists. This has been driven by the ubiquity of digital cameras and major increases in automation arising from scientific outputs from the computer vision discipline (e.g., interest operators, feature point matching, and dense point cloud extraction; Granshaw and Fraser, 2015), which have been implemented in easy-to-use software packages. In addition, new dynamic sensor platforms such as unmanned aerial vehicles (UAVs) and mobile mapping systems allow 3-D acquisition in a wide range of configurations, and extended-spectral-range imaging sensors (multispectral and hyperspectral, thermal, radar; Eitel et al., 2016) provide new possibilities for complementing purely geometric approaches (Buckley et al., 2013). Finally, societal policy shifts have moved toward making geospatial data freely available to the public through public- or private-sector initiatives (Krishnan et al., 2011; U.S. Geological Survey, 2017; Norwegian Mapping Authority, 2017).

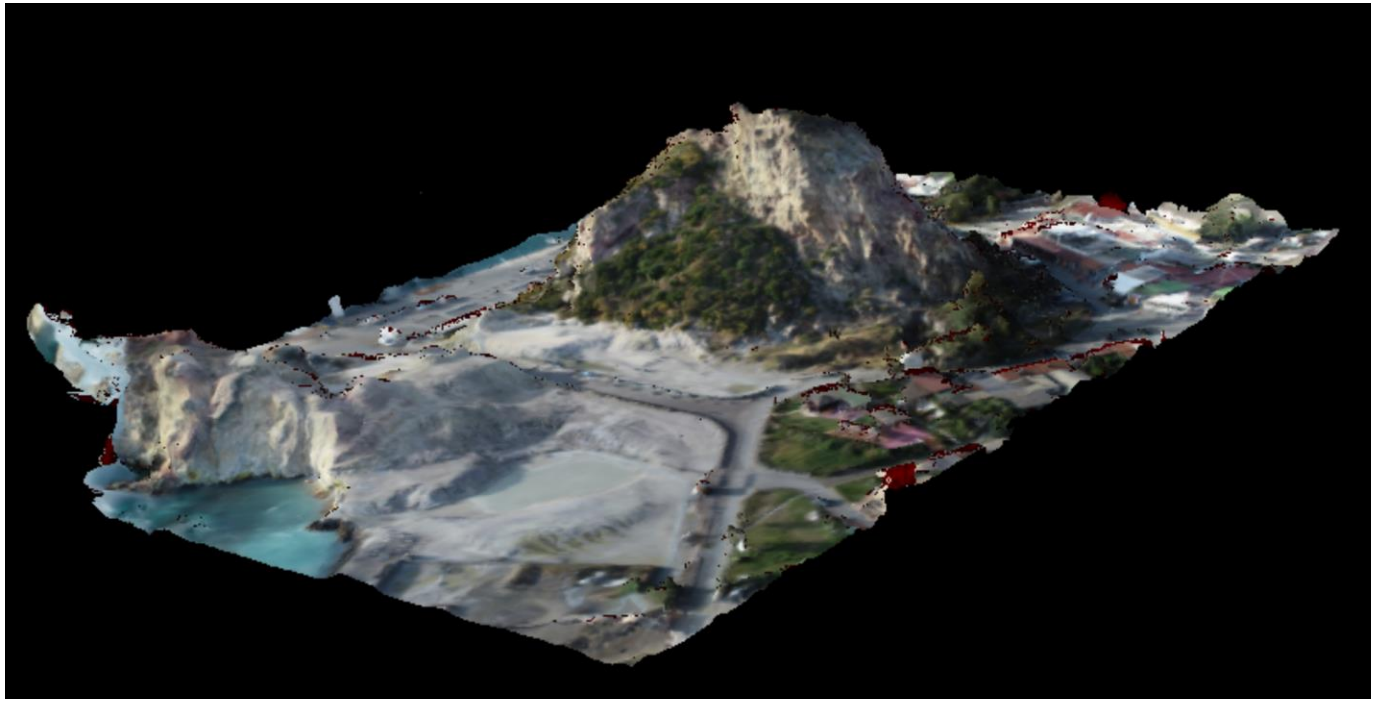
These developments have facilitated workflows for obtaining 3-D digital representations of surface topography across the range of scales (i.e., hand sample to regional elevation models). Consequently, geoscientists are

Downloaded from https://pubs.geoscienceworld.org/gsa/geosphere/article-pdf/doi/10.1130/GES02002.1/4610849/ges02002.pdf
by 14300

Step 1: Import the model

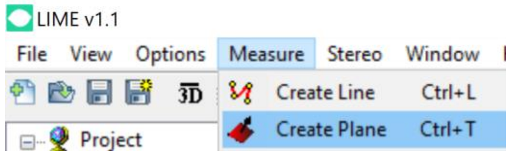


Import the .obj we built in Metahape as a 3D model. This is the textured mesh.

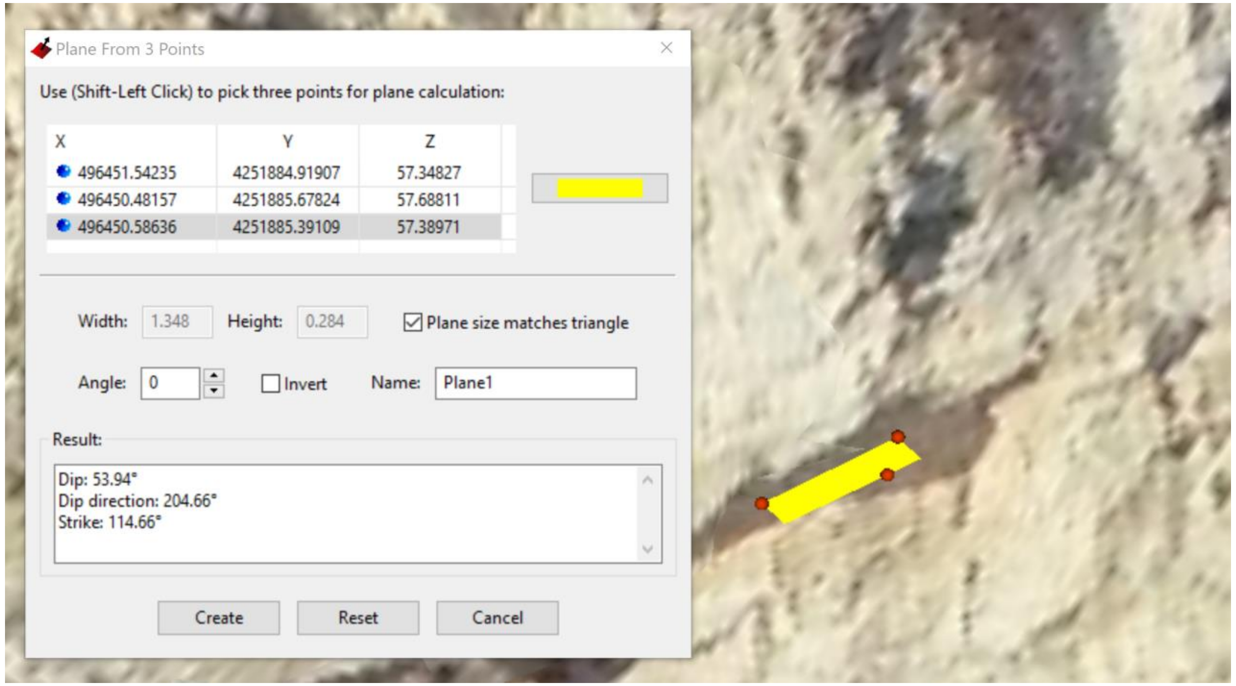


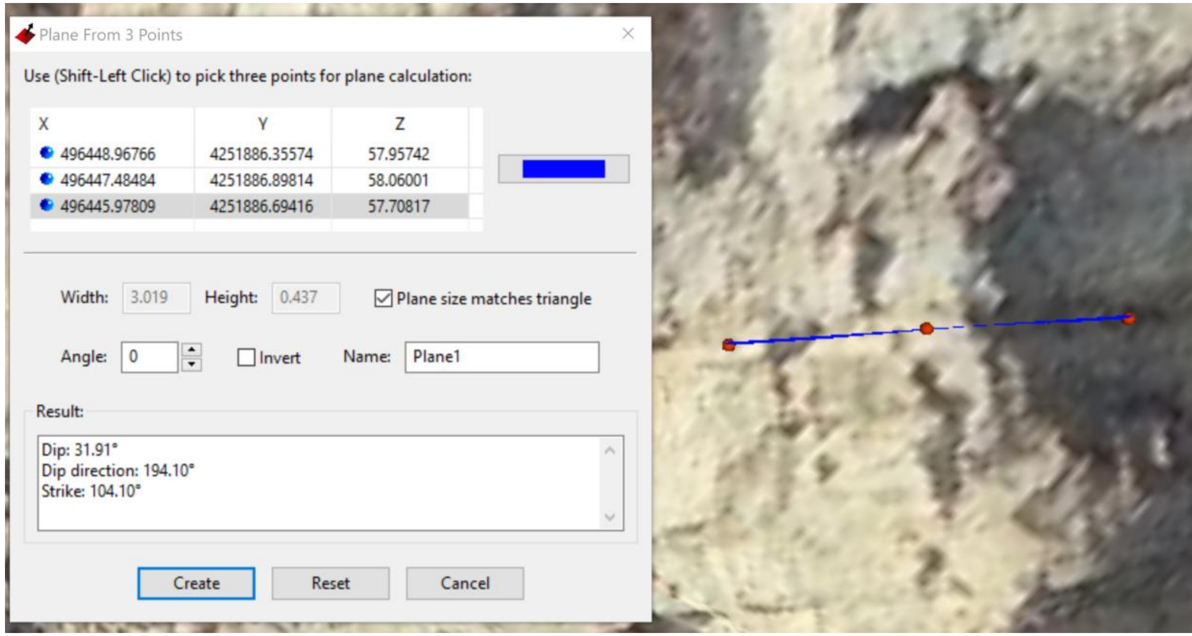
Let's navigate for a moment. Zoom in and out. Left click and drag to rotate. Double-click to move center point.

Step 2: Create a Plane



We can gather bedding data by clicking 3 points on a plane surface or in the plane direction.

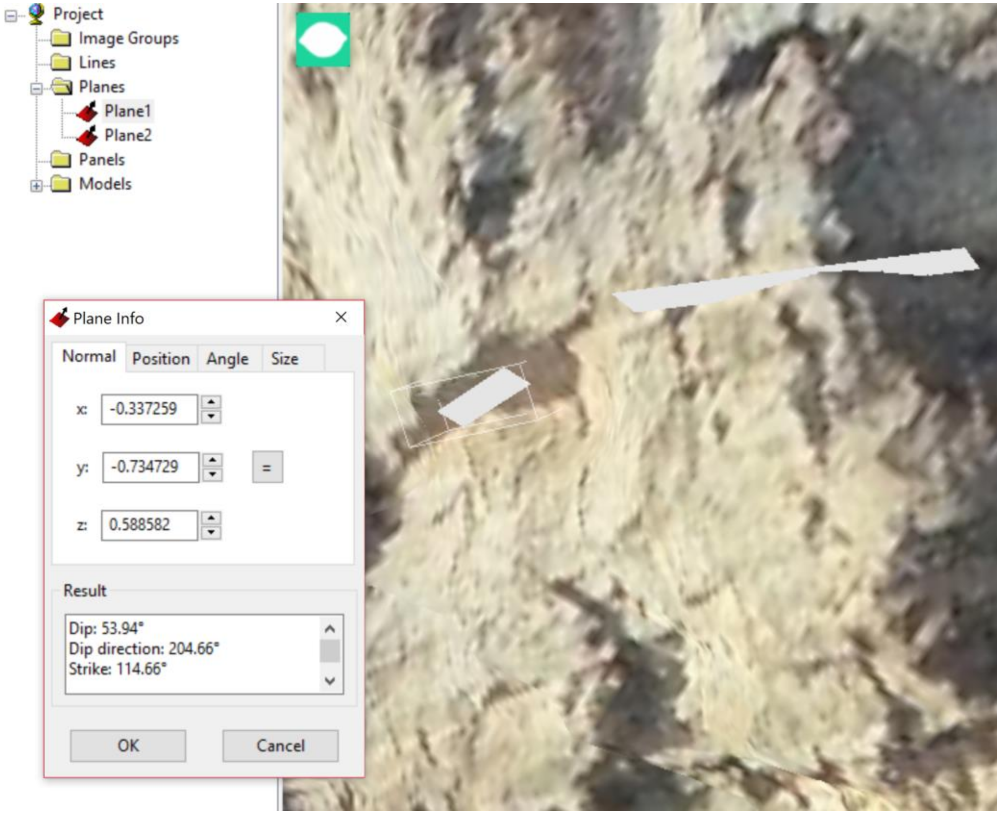


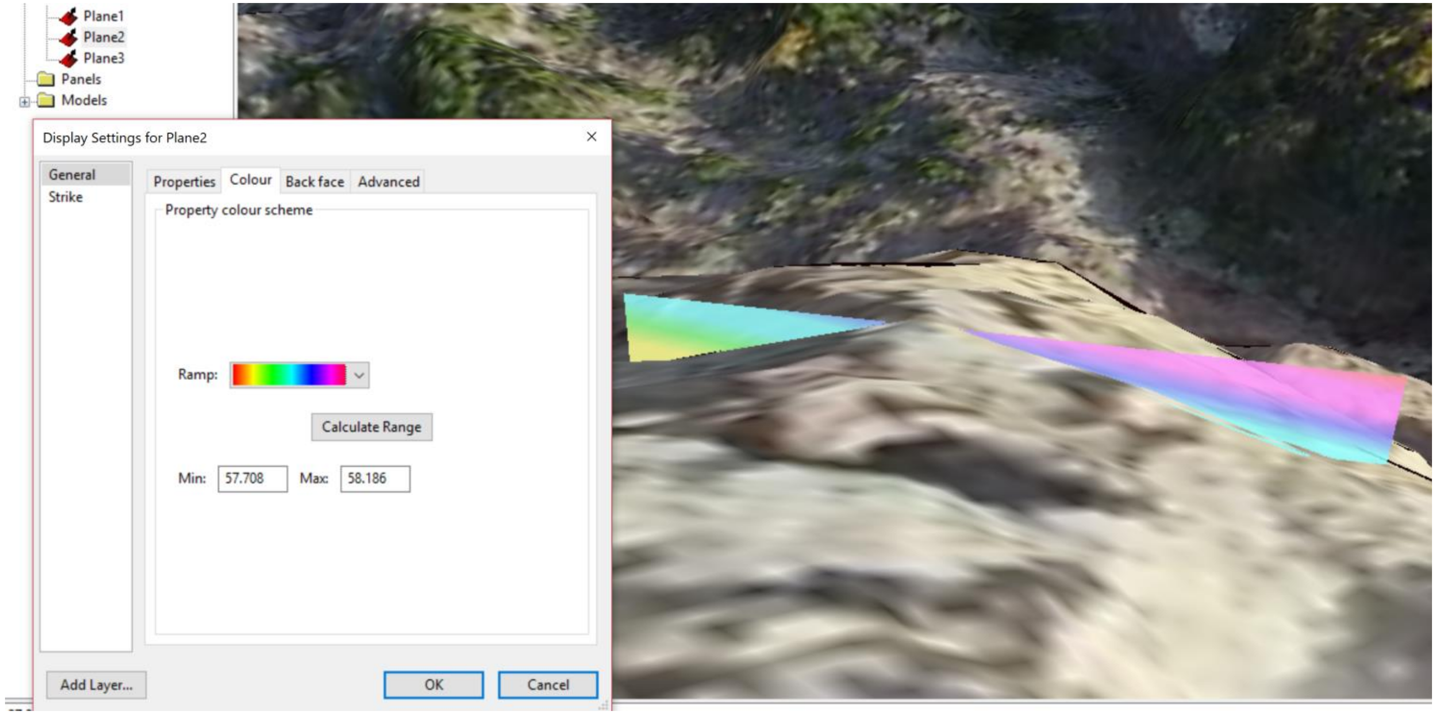


Hold shift and click to create plane. Let go of shift to move the model. Click create to move to next plane creation.

Step 2.5: Plane Properties

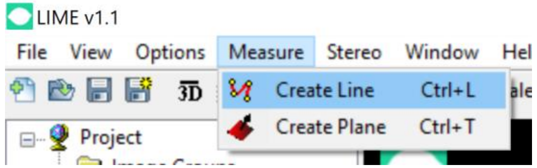
After we make the planes, review them in Planes workspace. Right click to display attributes, edit, etc.

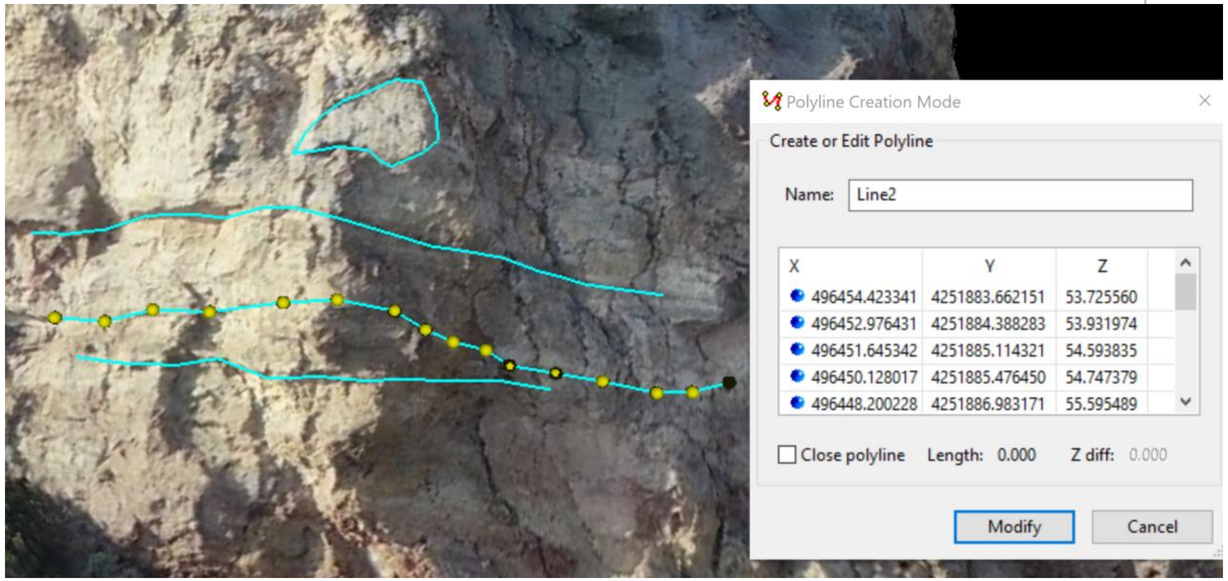




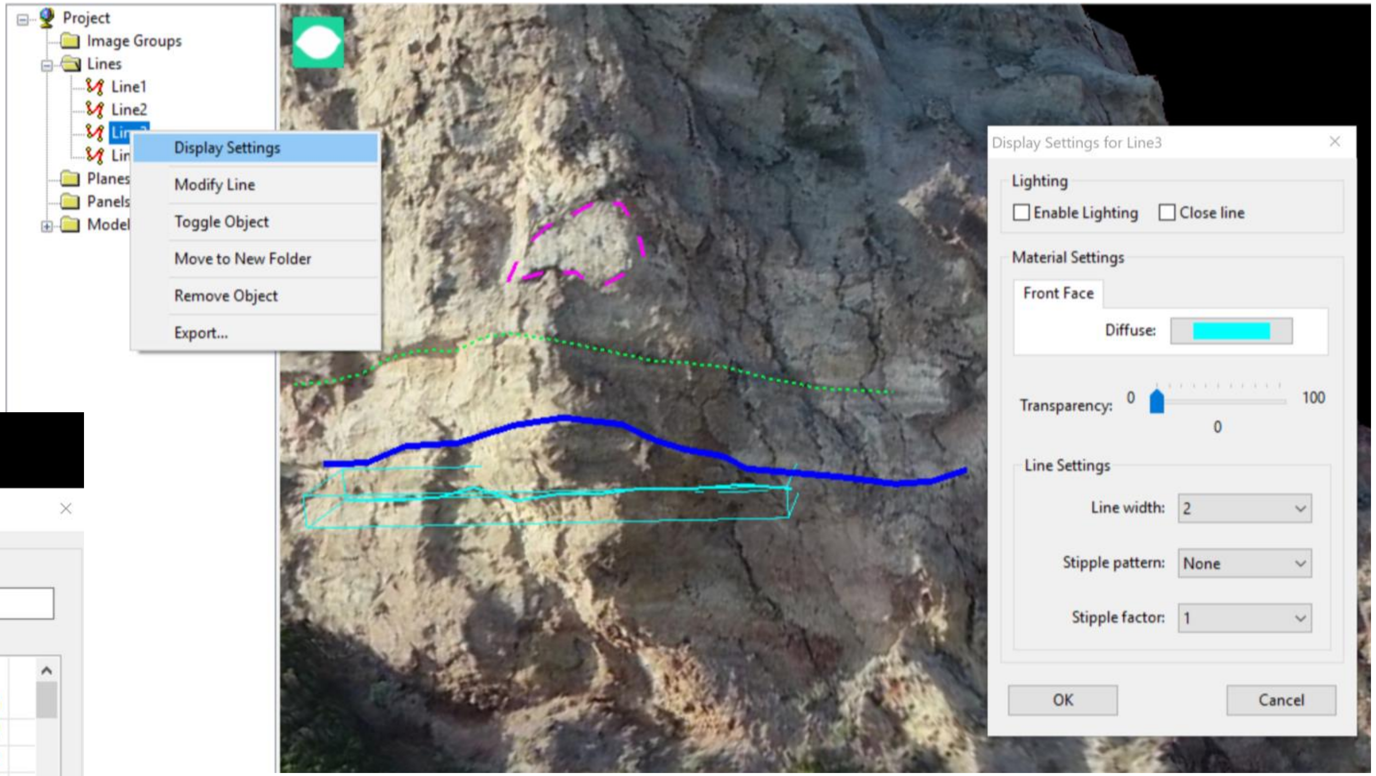
Here we will practice different ways to visualize the planes. You can add animations to the display with “Add Layer”.

Step 3: Create a Line



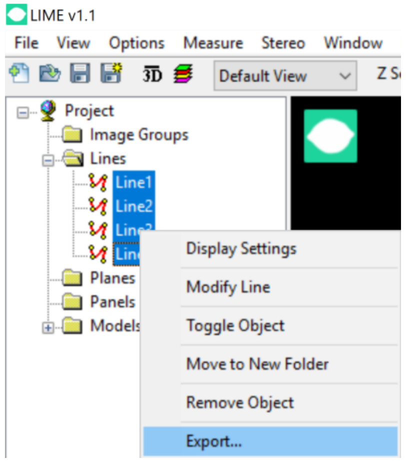


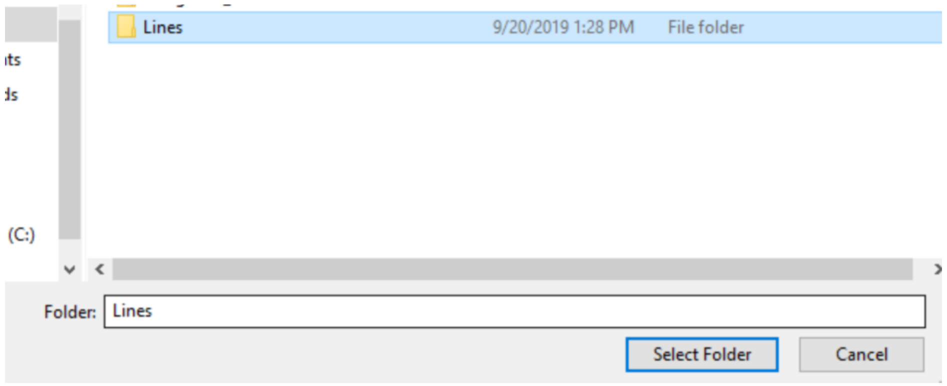
Hold Shift and click out the desired polyline. Let go of shift to move model. Click create to move to next polyline. To create a polygon select close polyline



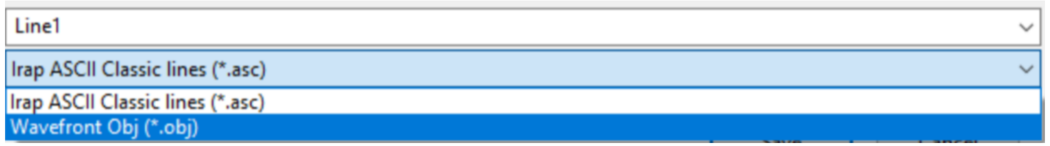
Right click on line in workspace to change display settings or modify the line.

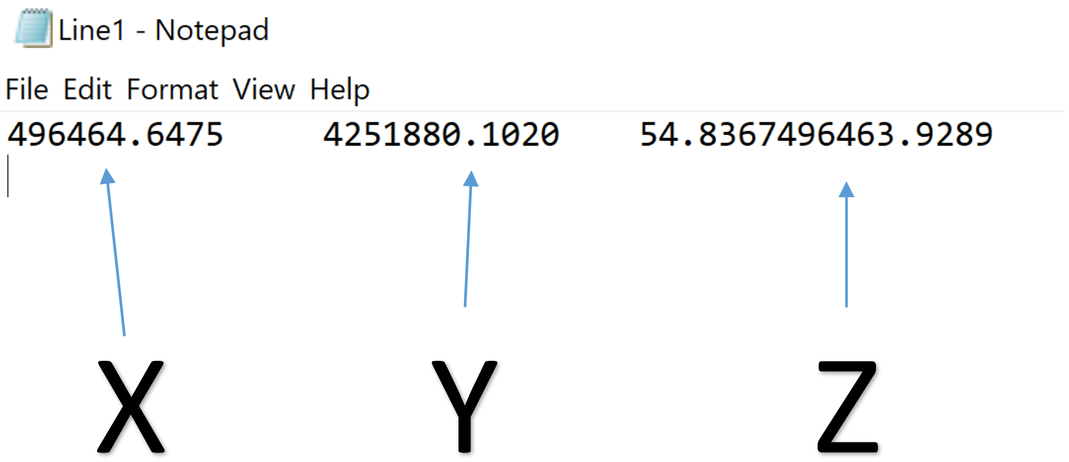
Step 3.5: Export a Line (ArcMap





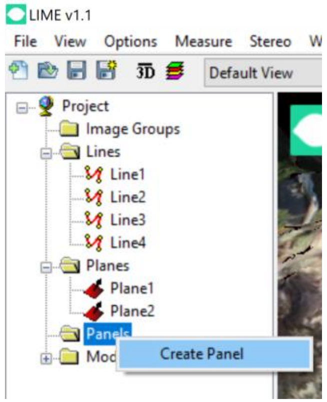
Exporting lines in bulk defaults to .asc file.
Simply create or choose a lines folder.
Exporting lines individually gives a .obj option.



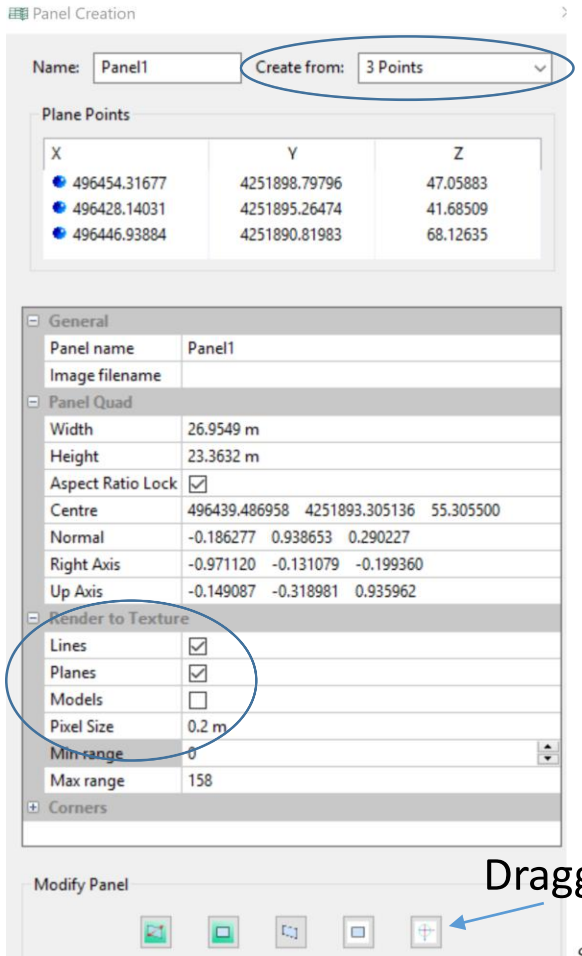


Import these files into 2D or 3D applications

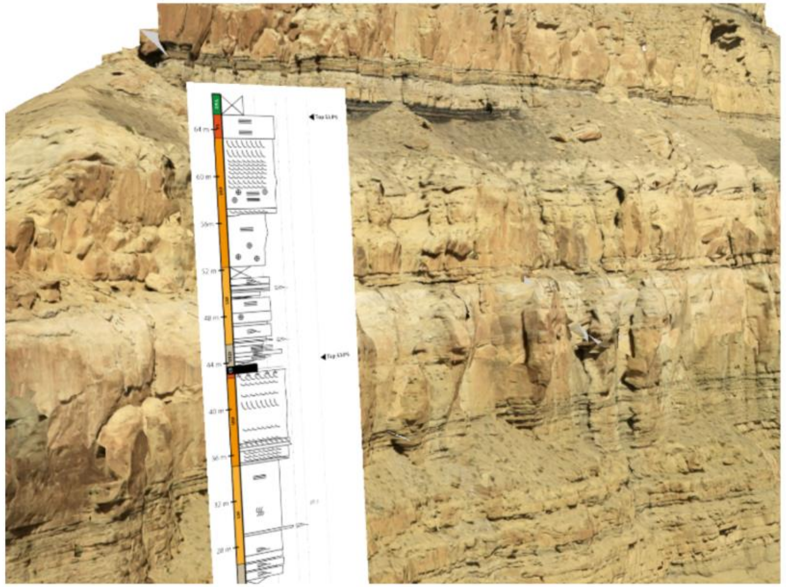
Step 4: Create a panel

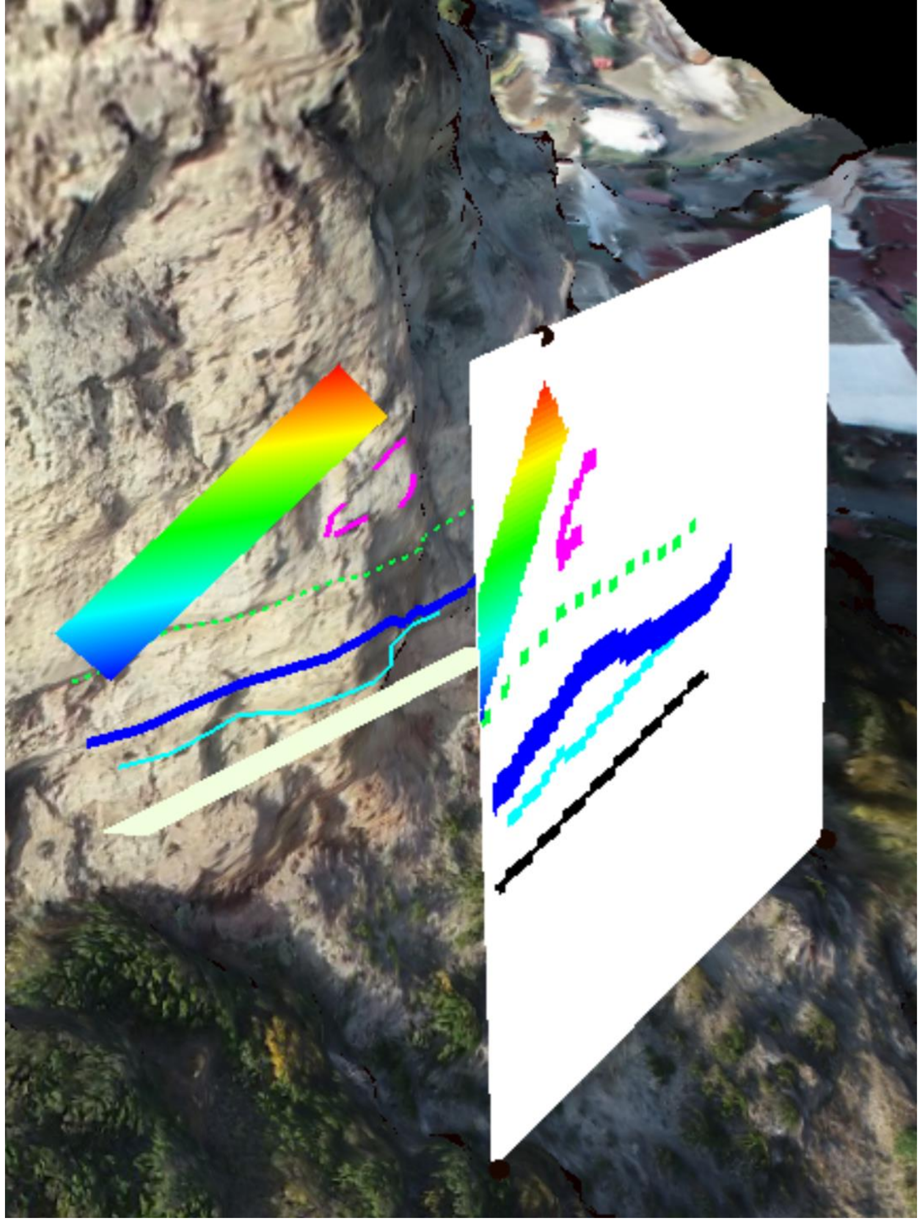


Project lines and planes onto a panel or import and image onto a panel



Choose the features you want projected and adjust pixel size for better visibility. Moving the panel is a tricky so use Draggers.





Project your lines and planes from Faraglione

Sedimentary log placed relative to outcrop model (courtesy of Dr Christian Haug Eide, University of Bergen).

Step 5: Stereo option