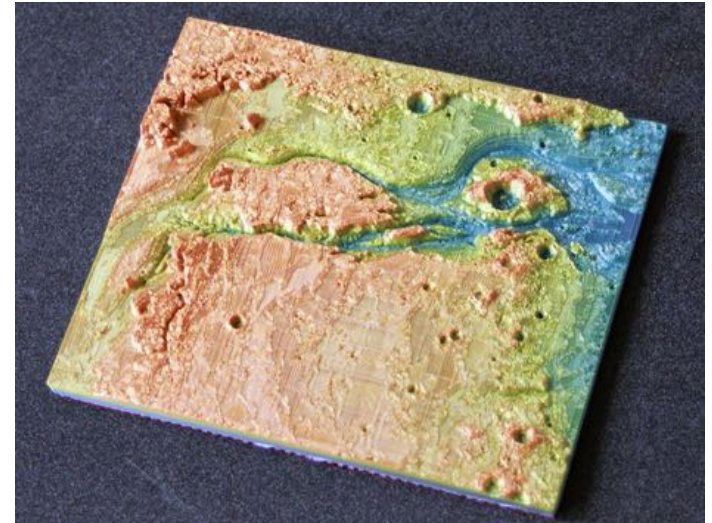


# Using 3D Terrain Data of Earth, Mars, and the Moon

**David Black, New Haven School, Spanish Fork, Utah**

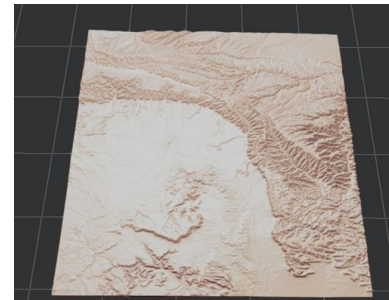
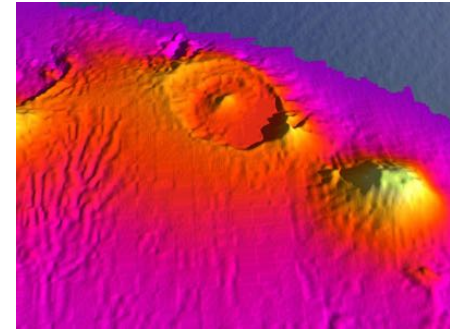
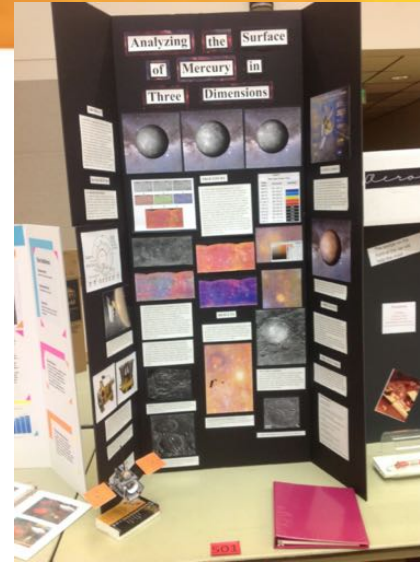
[elementsuneearthed@gmail.com](mailto:elementsuneearthed@gmail.com)

<http://spacedoutclassroom.com>



# Examples of Projects Using Big Data

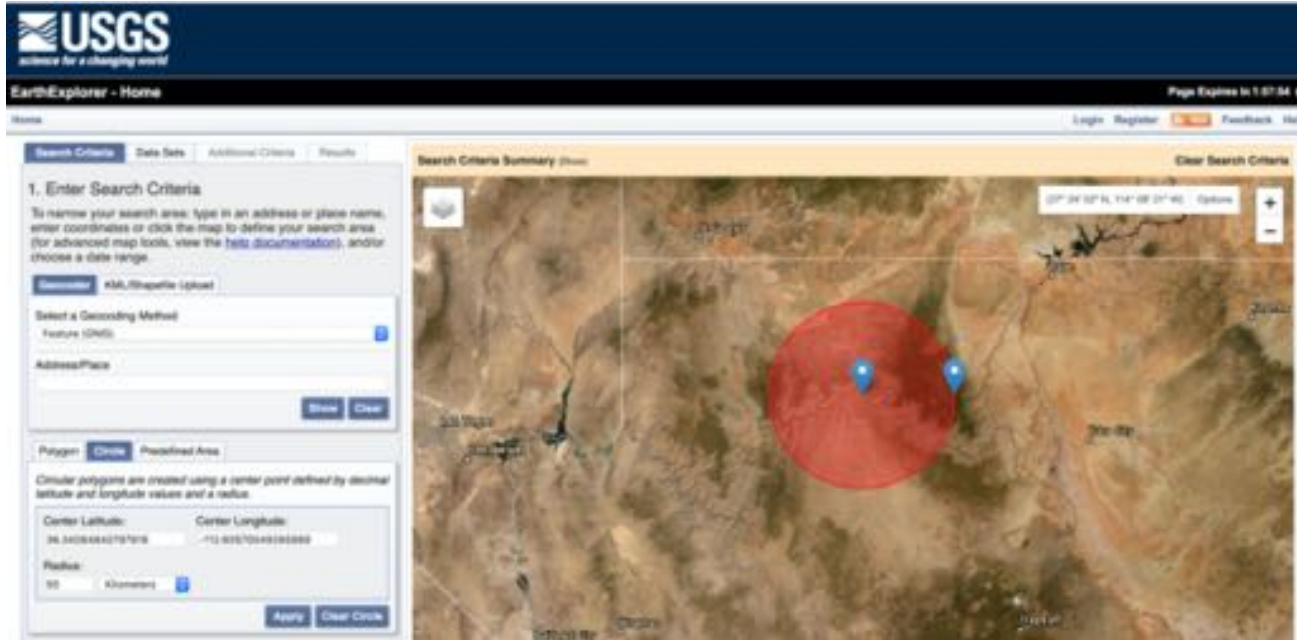
- Plate tectonics: Gunung Batur on Bali, uplift and erosion patterns of the San Rafael Swell and Book Cliffs, Utah.
- Narrow-band image data of Mercury from the MESSENGER space probe to determine if surface features are from impacts or volcanoes.
- Data from the Mars Reconnaissance Orbiter CRISM instrument to look for explosive volcanoes on Mars.
- Tutorial video on using Mars MOLA data: [https://youtu.be/kzdO9PANu\\_8](https://youtu.be/kzdO9PANu_8)



# Part 1: Finding the Data

## Earth Data: USGS EarthExplorer

- EarthExplorer is a one-stop site for geological and geographical data.
- It includes many data sets for the entire Earth.
- Use the map to define the area you want data from.



# Selecting Data Sets in EarthExplorer

- Under the **DataSets** tab at the bottom, you can select the type of data you want.
- For **Digital Elevation** models, the best resolution data is from the **Shuttle Radar Topography Mission**.
- **SRTM** covers  $55^{\circ}$  N to  $55^{\circ}$  S latitude.
- Use **GTOPO30** for other areas.
- Choose **Results** and select the best image, then download.

The screenshot shows the EarthExplorer interface. On the left, the 'Data Set Search' panel is open, showing a tree view of data categories. Under 'Digital Elevation', 'SRTM' is expanded, and 'SRTM 1 Arc-Second Global' is selected. Below the tree are buttons for 'Clear All Selected', 'Additional Criteria', and 'Results'. On the right, the '4. Search Results' panel is displayed. It contains a search bar with 'SRTM 1 Arc-Second Global' entered. Below the search bar, there are navigation controls and a list of three search results. Each result includes a thumbnail image, the entity ID, publication date, resolution, and coordinates. The first result is 'SRTM1N35W113V3', the second is 'SRTM1N36W113V3', and the third is 'SRTM1N36W114V3'. A large, detailed satellite image of a forested area is shown in the bottom right corner, corresponding to the search results.

# Mars MOLA Data

- Part of NASA Planetary Data System (PDS) Node for Geosciences at the Washington University in St. Louis (WUSTL)
- Choose **Mars** from the list at left and the **Mars Experimental Gridded Data Record (MEDGR)** link.
- Scroll to the bottom and choose the desired quadrant of Mars from the table according to latitude and longitude.

The screenshot shows the NASA National Aeronautics and Space Administration website for the PDS Geosciences Node. The header includes the NASA logo and the text "NATIONAL AERONAUTICS AND SPACE ADMINISTRATION". On the right, there are links for "+ NASA Homepage", "+ NASA en Español", and "+ Contact NASA". The main heading is "PDS Geosciences Node" with the subtitle "Washington University in St. Louis". Below this is a navigation bar with links for "HOME", "DATA AND SERVICES", "TOOLS", "ABOUT US", "CONTACT US", and "SITE MAP".

The left sidebar contains a "Services" section with links for "Analyst's Notebook", "Orbital Data Explorers", "Spectral Library", "Virtual Astronaut", "FTP Access", and "Workshops". Below that is the "Geosciences Node Data" section, which lists various Mars-related data sets, including "Mars Exploration", "Mars 2020", "InSight", "MSL", "MRO", "MER", "Mars Express", "Odyssey", "Phoenix", "MGS", "About MGS", "MOLA", "MOC", "TES", "MAG/ER", "Radio Science", "Accelerometer", "SPICE", "Pathfinder", "Prototype Rovers", "Viking Orbiter", "Viking Lander", "Mariner", and "Earth Based Data".

The main content area is titled "Mars Global Surveyor: MOLA". It contains a paragraph describing the Mars Orbiter Laser Altimeter (MOLA) and its data. Below this is a table of data products:

Raw Data Products	
Aggregated Experiment Data Records (AEDRs)	<a href="#">Online access</a>
Derived Data Products	
Precision Experiment Data Records (PEDRs): altimetry profiles	<a href="#">Online access</a>
Initial Experiment Gridded Data Records (IEGDRs)	Stored offline; available on request
Mission Experiment Gridded Data Records (MEGDRs): topographic maps	<a href="#">Online access</a>
Spherical harmonics model (SHADR)	<a href="#">Online access</a>
Passive Radiometry Data Records (PRDR)	<a href="#">Online access</a>

Below the table is an "Online Tools" section featuring a "Mars Orbital Data Explorer" tool, which provides search, display, and download tools for the data set.

At the bottom, there is a section titled "MOLA Products and IAU Coordinates" with a note: "The final version (Version L) of the MOLA PEDR data set was generated using the IAU 2000 coordinate system. The final version of the MOLA topographic maps..."

# Downloading MOLA Data

- Choose the Topography data, with prefix **MEGT**.
- Read the corresponding .LBL metadata file to see the numbers of rows and columns. You will need this information for ImageJ.
- The data is 16 bit signed data.
- This is the most detailed data, but a lower resolution image of all of Mars can be found at:

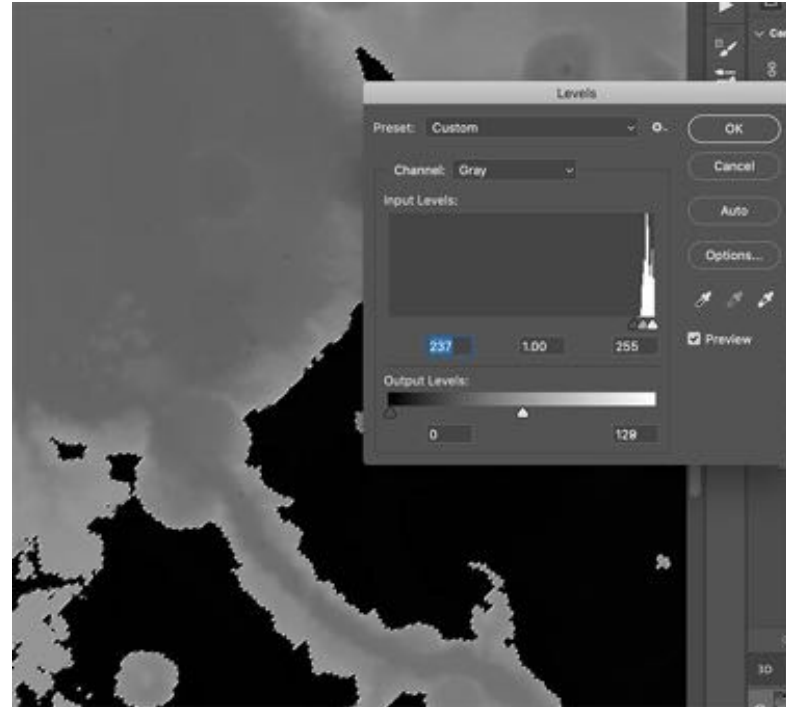
[http://astrogeology.usgs.gov/search/details/Mars/GlobalSurveyor/MOLA/Mars\\_MOLA\\_DEM\\_mosaic\\_global\\_463m/cub](http://astrogeology.usgs.gov/search/details/Mars/GlobalSurveyor/MOLA/Mars_MOLA_DEM_mosaic_global_463m/cub)

MEGDR Tiled Image Files and Labels at 128 Pixels Per Degree

<b>Area Covered</b>	88°N to 44°N lat, 0°E to 90°E lon	88°N to 44°N lat, 90°E to 180°E lon	88°N to 44°N lat, 180°E to 270°E lon	88°N to 44°N lat, 270°E to 360°E lon
<b>Counts</b>	megc88n000hb.img, megc88n000hb.lbl	megc88n090hb.img, megc88n090hb.lbl	megc88n180hb.img, megc88n180hb.lbl	megc88n270hb.img, megc88n270hb.lbl
<b>Radius</b>	megr88n000hb.img, megr88n000hb.lbl	megr88n090hb.img, megr88n090hb.lbl	megr88n180hb.img, megr88n180hb.lbl	megr88n270hb.img, megr88n270hb.lbl
<b>Topography</b>	megt88n000hb.img, megt88n000hb.lbl	megt88n090hb.img, megt88n090hb.lbl	megt88n180hb.img, megt88n180hb.lbl	megt88n270hb.img, megt88n270hb.lbl
<b>Area Covered</b>	44°N to 0° lat, 0°E to 90°E lon	44°N to 0° lat, 90°E to 180°E lon	44°N to 0° lat, 180°E to 270°E lon	44°N to 0° lat, 270°E to 360°E lon
<b>Counts</b>	megc44n000hb.img, megc44n000hb.lbl	megc44n090hb.img, megc44n090hb.lbl	megc44n180hb.img, megc44n180hb.lbl	megc44n270hb.img, megc44n270hb.lbl
<b>Radius</b>	megr44n000hb.img, megr44n000hb.lbl	megr44n090hb.img, megr44n090hb.lbl	megr44n180hb.img, megr44n180hb.lbl	megr44n270hb.img, megr44n270hb.lbl
<b>Topography</b>	megt44n000hb.img, megt44n000hb.lbl	megt44n090hb.img, megt44n090hb.lbl	megt44n180hb.img, megt44n180hb.lbl	megt44n270hb.img, megt44n270hb.lbl
<b>Area Covered</b>	0° to 44°S lat, 0°E to 90°E lon	0° to 44°S lat, 90°E to 180°E lon	0° to 44°S lat, 180°E to 270°E lon	0° to 44°S lat, 270°E to 360°E lon
<b>Counts</b>	megc00n000hb.img, megc00n000hb.lbl	megc00n090hb.img, megc00n090hb.lbl	megc00n180hb.img, megc00n180hb.lbl	megc00n270hb.img, megc00n270hb.lbl
<b>Radius</b>	megr00n000hb.img, megr00n000hb.lbl	megr00n090hb.img, megr00n090hb.lbl	megr00n180hb.img, megr00n180hb.lbl	megr00n270hb.img, megr00n270hb.lbl
<b>Topography</b>	megt00n000hb.img, megt00n000hb.lbl	megt00n090hb.img, megt00n090hb.lbl	megt00n180hb.img, megt00n180hb.lbl	megt00n270hb.img, megt00n270hb.lbl
<b>Area Covered</b>	44°S to 88°S lat, 0°E to 90°E lon	44°S to 88°S lat, 90°E to 180°E lon	44°S to 88°S lat, 180°E to 270°E lon	44°S to 88°S lat, 270°E to 360°E lon
<b>Counts</b>	megc44s000hb.img, megc44s000hb.lbl	megc44s090hb.img, megc44s090hb.lbl	megc44s180hb.img, megc44s180hb.lbl	megc44s270hb.img, megc44s270hb.lbl
<b>Radius</b>	megr44s000hb.img, megr44s000hb.lbl	megr44s090hb.img, megr44s090hb.lbl	megr44s180hb.img, megr44s180hb.lbl	megr44s270hb.img, megr44s270hb.lbl
<b>Topography</b>	megt44s000hb.img, megt44s000hb.lbl	megt44s090hb.img, megt44s090hb.lbl	megt44s180hb.img, megt44s180hb.lbl	megt44s270hb.img, megt44s270hb.lbl

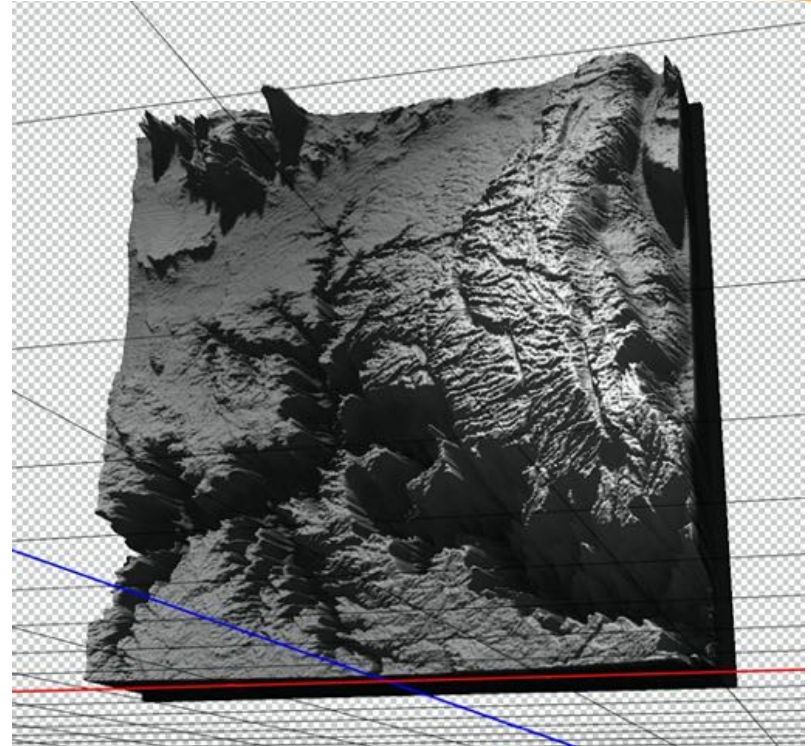
# Fixing the Bi-Gradient Problem

- Open the global TIFF file in Adobe Photoshop. It will have a light area and a dark area, which are both gradients.
- Use the magic wand tool set to a tolerance of 50 and with contiguous and anti-aliasing turned off to select the light area (low altitude).
- Choose **Image-Adjustments-Levels** and move the white output slider to **128** and the black input slider to the edge of the curve.
- Inverse the selection and choose **Image-Adjustments-Levels** again. Move the black output slider to **128** and the white input slider to the edge of the curve.



# Part 2: Turning the Heightmap into a 3D Model

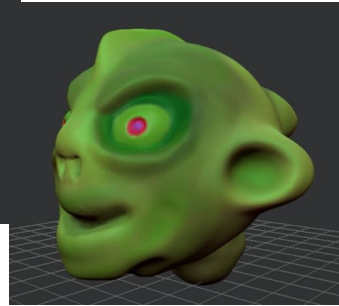
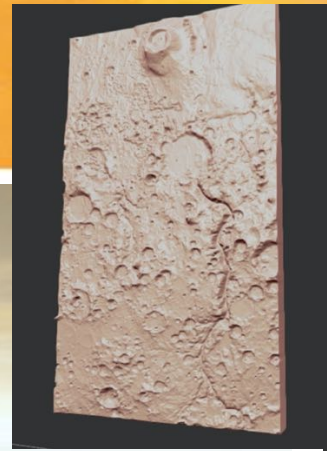
- Open the saved heightmap into Adobe Photoshop (newer version).
- Select and crop the part you want.
- Choose **3D**, then **New Mesh from Layer**, then **Depth Map to**, then **Solid Extrusion**.
- A model will appear in a few moments. It will have exaggerated height.
- Choose **3D**, then **Export 3D Layer**, and save as a **WavefrontOBJ**.
- You won't want to 3D print this yet - it will crack through the lowest elevation.





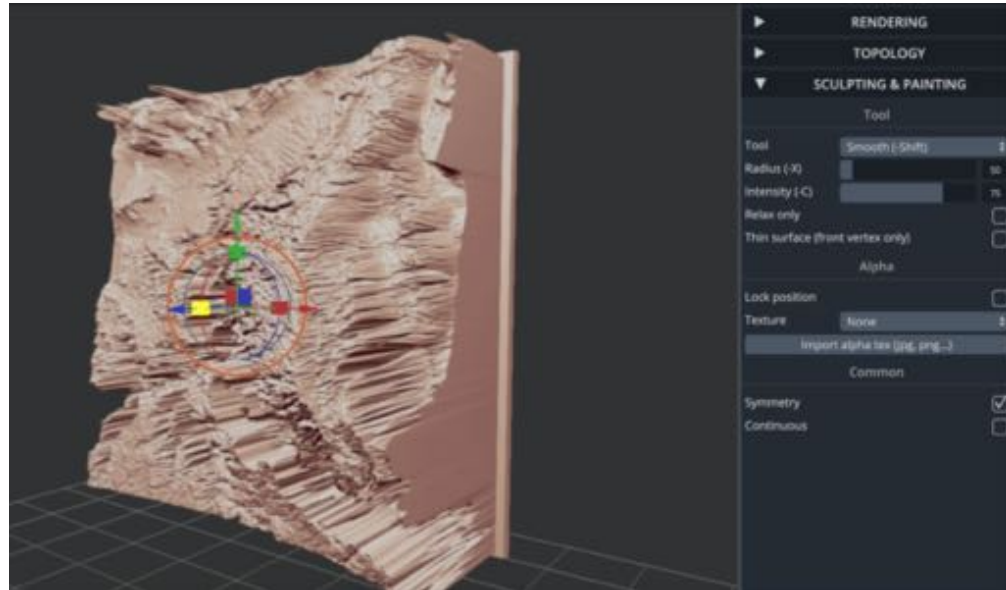
# SculptGL

- SculptGL is an online browser-based 3D modeling platform. It can be used to model and paint many organic shapes.
- Easy tool set that can take a virtual ball of clay and pull and push it, adding polygons automatically as you go.
- Examples: Creating 3D portraits of famous scientists or alien life forms.



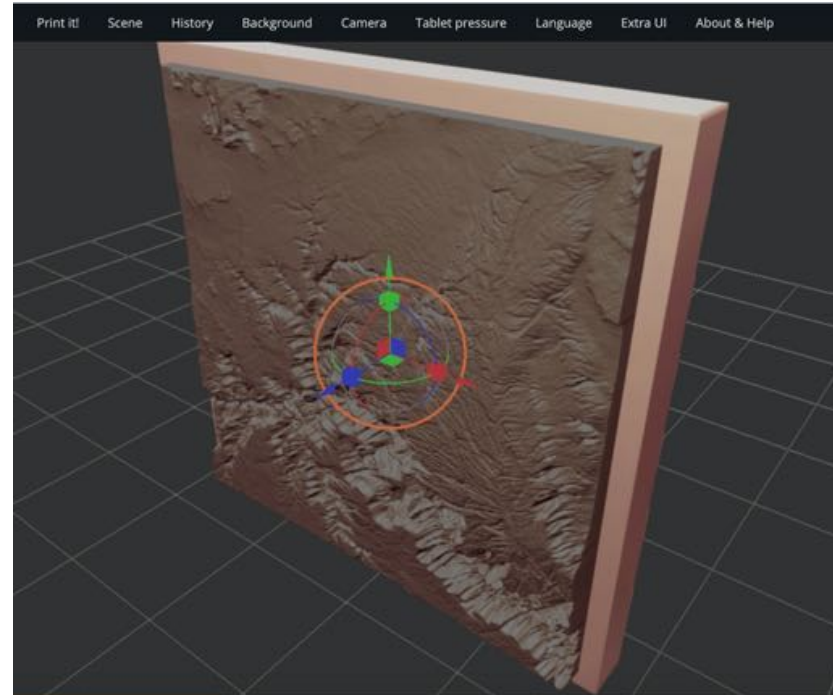
# Flattening the Model in SculptGL

- Inside **SculptGL**, choose **Scene**, then **Clear Scene** to get rid of the clay ball.
- Import your terrain model.
- To flatten the height, choose the **Transform** tool in the pull-down **Tool** menu on the right.
- Choose the blue box (not the arrow or arc). It will turn yellow. Push it in to flatten until the height of the model looks realistic.



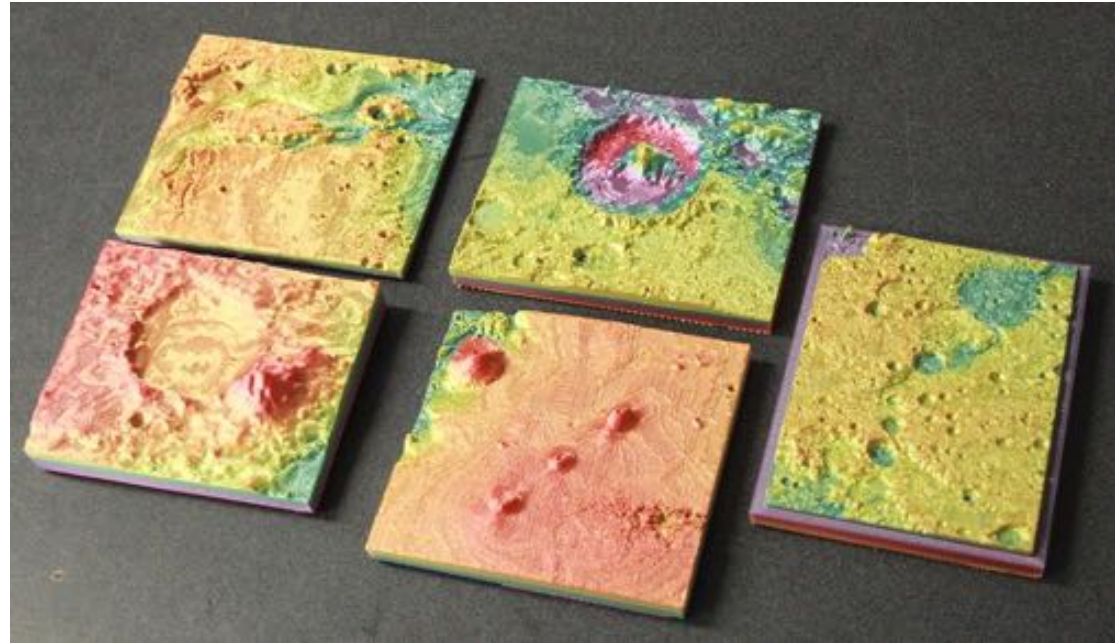
# Adding a Base in SculptGL

- Choose **Scene**, then **Add Cube**. A large cube will appear and will be selected - the terrain will go dark (unselected).
- Use the **Transform** tool to shrink the cube and move it so that it is just barely touching the bottom of the terrain.
- Select both objects by holding down **Shift** and clicking on them.
- Choose **Scene**, then **Merge Selection**.
- Export the model as an .obj or .stl file. It is now suitable for 3D printing.



# 3D Printing

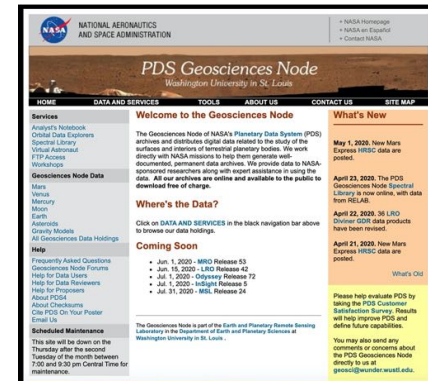
- Once the models are merged, you will need to reduce their resolution to make them printable.
- Using the Topology pull down menu, move the slider to about 250, then choose **Remesh**.
- The model can now be exported as an .STL or .OBJ and sliced and printed in your favorite slicer software.



# Other Sources of Big Data

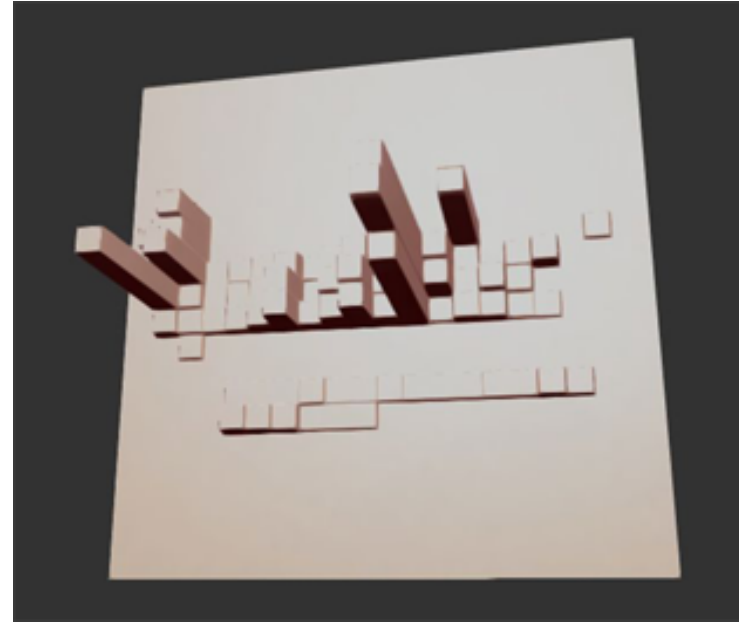
- NASA Geosciences Data:
- NASA Image Data:
- NOAA data (oceans, weather, climate):
- CDC Disease Data:
- U.S. Census Bureau (demographics, population, voting):
- Infrared Astronomy Data - IPAC.
- The challenge is to find raw data that hasn't already been interpreted and the tools to manipulate it.

<https://pds-geosciences.wustl.edu/>  
<https://photojournal.jpl.nasa.gov/>  
<https://data.noaa.gov/datasetsearch/>  
<https://www.cdc.gov/datastatistics/index.html>  
<https://data.census.gov/cedsci/>  
<https://irsa.ipac.caltech.edu/frontpage/>



# Or Use Your Own Field Data

- Field research can gather data on environmental conditions such as water or soil quality.
- If tied to geographic or GPS data, it creates a grid of numbers.
- If all the rows are of equal length, then the data can be loaded into ImageJ from the National Institutes of Health by importing it as a **Text Image**.
- It will create a grayscale image with the highest number white and the lowest number black.
- This image can become a heightmap for 3D modeling.



Questions? Contact David Black at:  
[elementsunearthed@gmail.com](mailto:elementsunearthed@gmail.com)