Data structures for elevation – some sample data from the Environment Agency of England and Wales

Overview

In this exercise, we will take a look at the different data structures that can be used to store elevation data in ArcGIS Pro. Understanding how the different data structures work can be helpful in deciding when to use them. We will look at three data structures:

- Raster grids;
- Vector contour lines;
- Triangulated irregular networks (TINs)

As our case study site, we will look at an area of saltmarsh on the Hampshire coast. The area, near Lymington, was formerly used for production of salt, so sea walls were constructed historically to produce saltings, shallow ponds from which sea water would evaporate to produce brine. Much of the area is now saltmarsh, an important habitat for conservation and for many other ecosystem functions such as carbon sequestration (see https://www.ceh.ac.uk/our-science/projects/salt-marshes). Typically, elevation is an important determinant of the composition of saltmarsh ecological communities, with pioneer species found at the lowest elevations, then lower and upper saltmarsh species becoming more predominant as elevation increases and tidal inundation decreases.

Data File

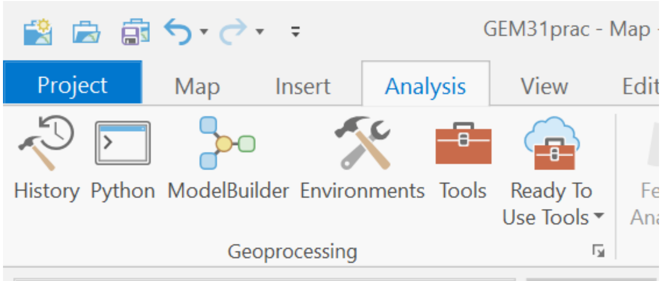
For the exercise, we have downloaded a 2-metre resolution Digital Surface Model (DSM) produced using lidar data (see elsewhere in the module for more on this) from the Environment Agency for England and Wales. It is in raster format and was downloaded from here:

https://environment.data.gov.uk/DefraDataDownload/?Mode=survey

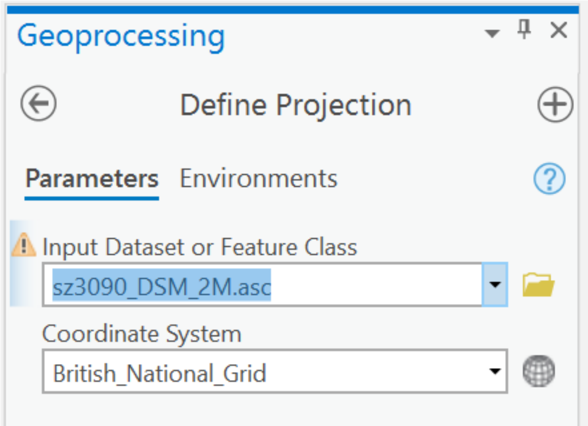
It covers a 1km by 1km tile with 2 metre pixel resolution and is named **SZ3090_DSM_2M.ASC**. The last part of the file name reflects the data product (DSM) and its resolution (2M). The first part of the file name reflects its location on the Ordnance Survey National Grid (for an explanation, see https://www.ordnancesurvey.co.uk/documents/resources/guide-to-nationalgrid.pdf).

Practical Instructions:

Start up ArcGIS Pro, setting up a new project for this exercise using the *Map* template. Using the right-hand ArcCatalog window, connect to the folder with the data for this exercise and drag and drop our raster layer into the map window. It will probably appear in the wrong place, so our first job will be to define the coordinate reference system used in the file, so as to correct this problem. To do this, we need to activate the ArcToolBox. Head for the *analysis* menu and click on the *Tools* icon to open up the *GeoProcessing* panel to the right of your screen:



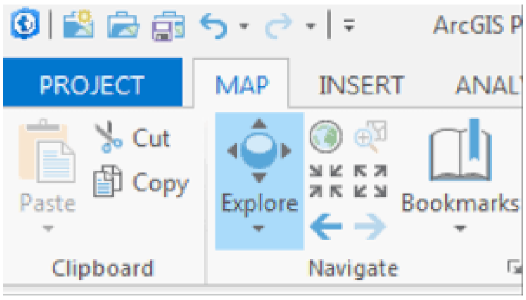
Within the *geoprocessing* panel that now appears on the right, type 'define' into the search box to find the *define projection* tool, then run this tool. Choose our elevation map layer and under '*coordinate system'*, find the British National Grid under *National Grids / Europe:*



If you run the tool, it should now document the raster coordinates as being based on the British National Grid. Note that when you run tools in ArcGIS Pro, the *View details* and *open history* options for the tool are a good way of finding out if a tool has run successfully and what settings you chose for it.

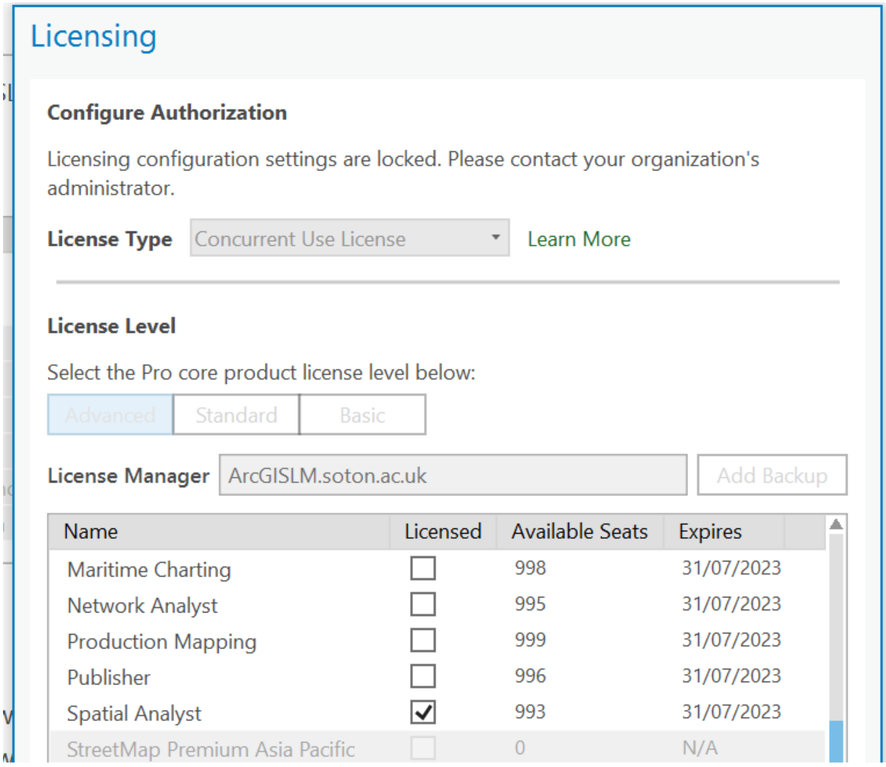
If you right-click on your layer in the left-hand panel and choose *zoom to layer*, you should now be able to see it lining up correctly on the Hampshire coast, now that its coordinate system is properly recorded. Note that if you have background layers displayed, you may need to either change the drawing order in the left-hand panel or else drag your layer so that it is at the top of the *drawing order* and is not obscured by other layers.

If you zoom in and out (you can do this via the wheel on your mouse using the *explore* button, visible after clicking on *map* in the menus), you should be able to see the raster structure of your data.



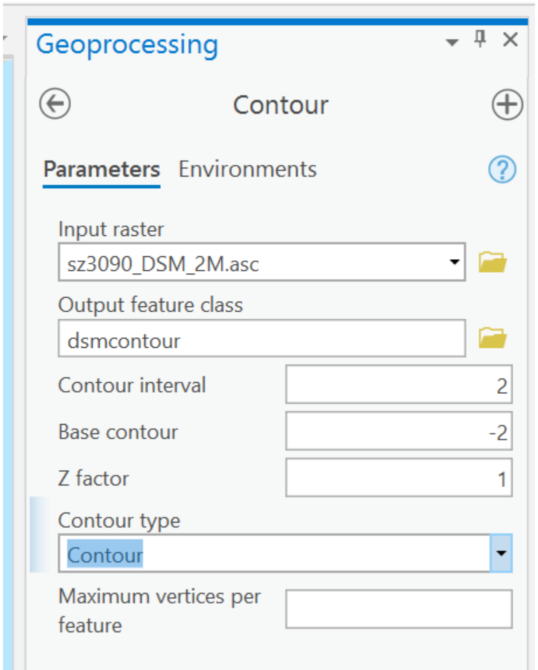
We can convert our data to other formats via some of the other tools available within Pro. However, since the tools are only available to those with the relevant extension (add-in) licences, we first need to activate these licences. There are two extensions of particular relevance: *spatial analyst*, used for processing raster layers, such as our grid, and *3D analyst*, used particularly with elevation layers and data.

To activate these licences, head for the *file* menu, then *licencing,* then choose *configure your licencing options.* At this screen, make sure you select *3D Analyst* and *Spatial Analyst*:



After activating the licences, use the ‘Back’ button (top left with an arrow icon) to come back to the main ArcPro screen. Go back to the geoprocessing panel and search for ‘contour’ – this will enable us to generate contour lines from raster grid.

When you find the tool, try running it on our elevation layer. In the example below, I have set up the tool to produce contour lines every 2 metres (via the *contour interval* setting), starting at 2 metres below sea level (**-2** as the *base contour* setting), given that this is saltmarsh. The tool can take some time to run, so we recommend using a fairly wide contouring interval:

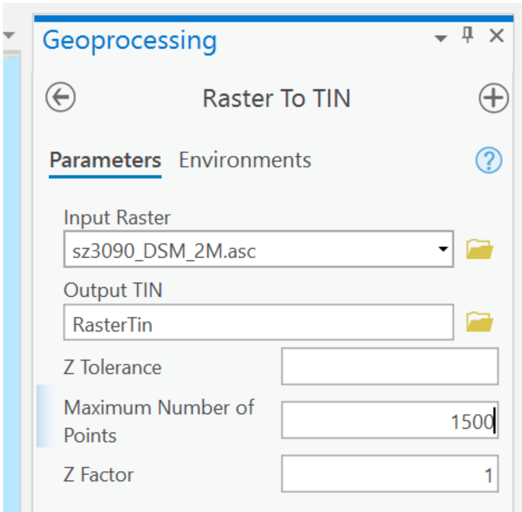


When the tool has run (it may take a while), take a look at the resultant contours. You may need to turn off the visibility of your other layers or change the drawing order to see it. You should also use the *explore* button and the left-hand mouse button to look at the attributes for particular features; you can also right-click on the layer in the left-hand panel and look at its *attribute table*.

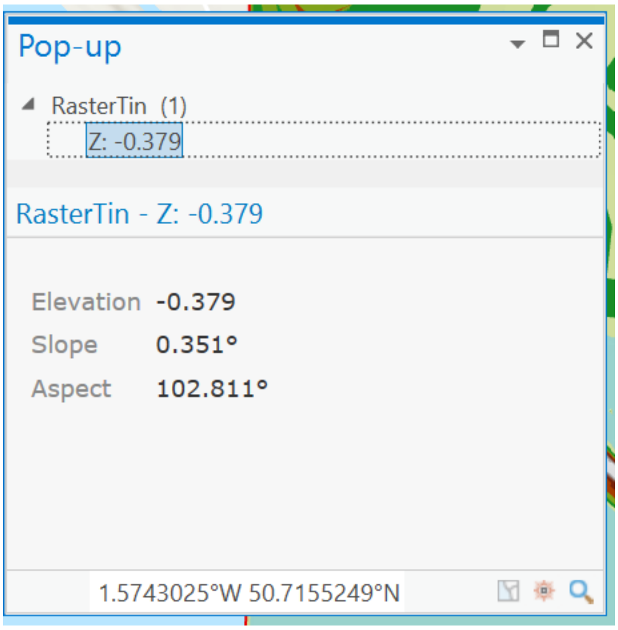
Questions to think about:

- What do you notice about the density of contours in different parts of the study site?
- What could the resultant contour layer be used for?

Finally, let us try and convert our elevation layer into Triangulated Irregular Network (TIN) format. To do this, head for the *geoprocessing* panel on the right-hand side again, and this time, search for 'TIN'. Let us run the tool called 'raster to TIN'. It can take a look time to generate a TIN, so we strongly recommend limiting the *maximum number of points* to say **1500** (you can ignore other settings for now):

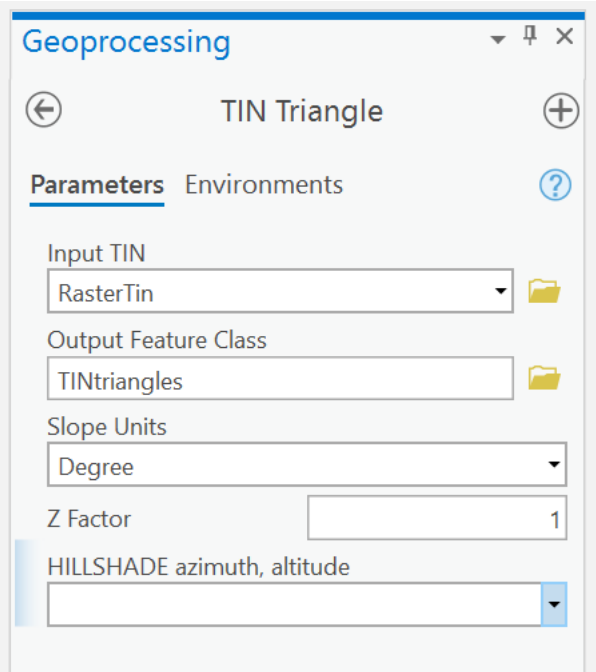


Do not be concerned if you see a warning message about the maximum number of points when you run the tool – that is simply because we set it quite low. Once it has run (it may take a while), make sure it is visible. Its triangulated structure may not be obvious when you zoom in. If you use the left-hand mouse button and the *explore* tool again, you should be able to see the attributes stored in each triangle:

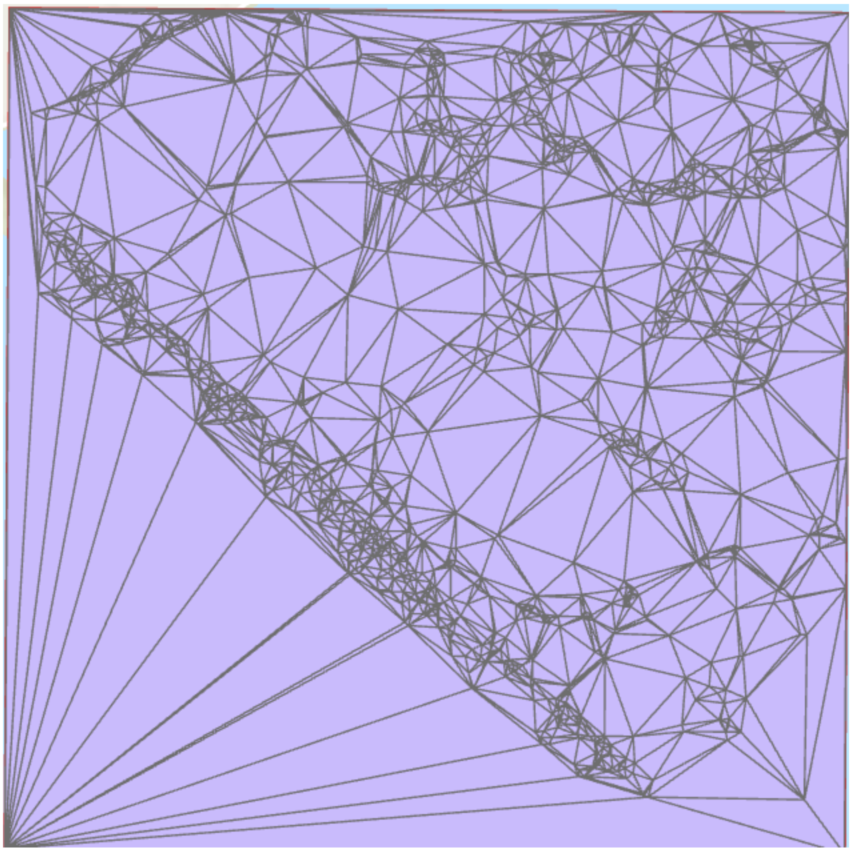


Where you click, you will see an estimated elevation, as well as a slope (gradient in degrees) and aspect (direction of slope, indicating the direction in which the slope faces). However, the structure of the TIN may still not be that obvious to you.

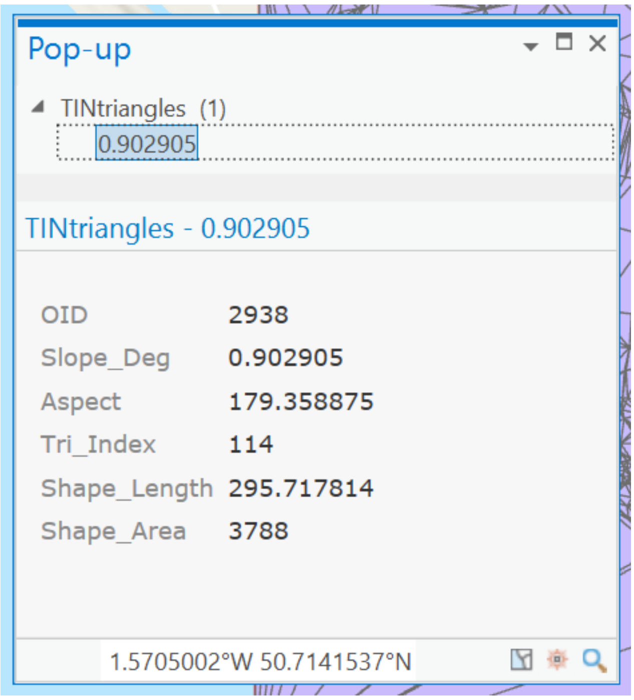
If you go back to the geoprocessing toolbox and search again, you should be able to find the **TIN Triangle** tool. This tool generates a set of vector triangles, which reflect the structure of the TIN. Try it out:



Again, the tool might take a while to run, so be patient. Once it has run, take a look at the output layer. You should see something like this:



Notice how the space has been divided (tessellated) into a set of interlocking triangles. Each triangle's corner or node contains an elevation value and these can be used to compute the gradient or slope and aspect (orientation or direction of slope) for each triangle. You can see this when you click on the triangles with the *explore* button to view their attributes:



Note that Tri_index is simply a unique identifier for each triangle – no two triangles will share the same value for Tri_index. The slope and area of each triangle are also stored in attribute fields. Notice also that the density of triangles varies depending on terrain complexity: the sea wall has many small triangles, whereas flatter areas have few, large triangles.

You may wish to try out the *TIN node* and *TIN edge* tools as well and explore their outputs. This will create vector feature classes for the 'corners' of each triangle (known as nodes) and their sides (known as edges).

Questions:

- What potential advantages and uses do you see for elevation data stored as a TIN?
- Do you have any observations about the level of detail in the terrain representation as it is changed between TIN, vector and raster formats?