The Relationship between Temperature and Elevation in the La Sal Mountains

Introduction:

In this study, a raster model of temperature was created to evaluate the model to see if there are extrapolated values among the grid cells in the temperature raster and to determine if the raster model follows the predicted relationship between elevation and temperature. The predicted relationship between elevation and temperature is that changes in elevation can determine the observed differences in temperature. This study took place in Utah in the La Sal Mountains and the data used for the raster model is from the 2008 annual temperatures. Two kinds of data were used for this study, temperature and elevation. The temperature was collected by Dr. Joseph Nicholas using data loggers that recorded the temperature of each data station every 10 minutes in degrees Celsius. The elevation data is from the 2020 National Elevation Dataset collected by the United States Geological Survey in meters.

Topographic Characteristics:

Elevation, slope, and aspect affect the way temperatures differ across the La Sal Mountains. The slope helps to contextualize how elevation changes with distance and how that may affect certain variables such as temperature, erosion, run-off, etc. Aspect works alongside slope since it determines the direction the slope is facing and that can determine if a slope receives less solar radiation, impacting temperature and evaporation rates. Due to the way these variables affect temperature, it is crucial to know the elevations, slopes, and aspects of the input data points from which the temperature raster will be interpolated. From the eight data stations shown in the elevation map (Figure 1), a wide range of elevations are represented. Additionally, when looking at all collected data stations there is a similar range of elevations (Table 1). The data stations shown in the table also have a variety of slopes and aspects that are evident by how the lowest slope value is 3.08 and the highest goes up to 42.65. The lowest aspect value is 2.12 and the highest is 357.43, also showing a wide range of values. Overall, the topography of the La Sal Mountains is varied.

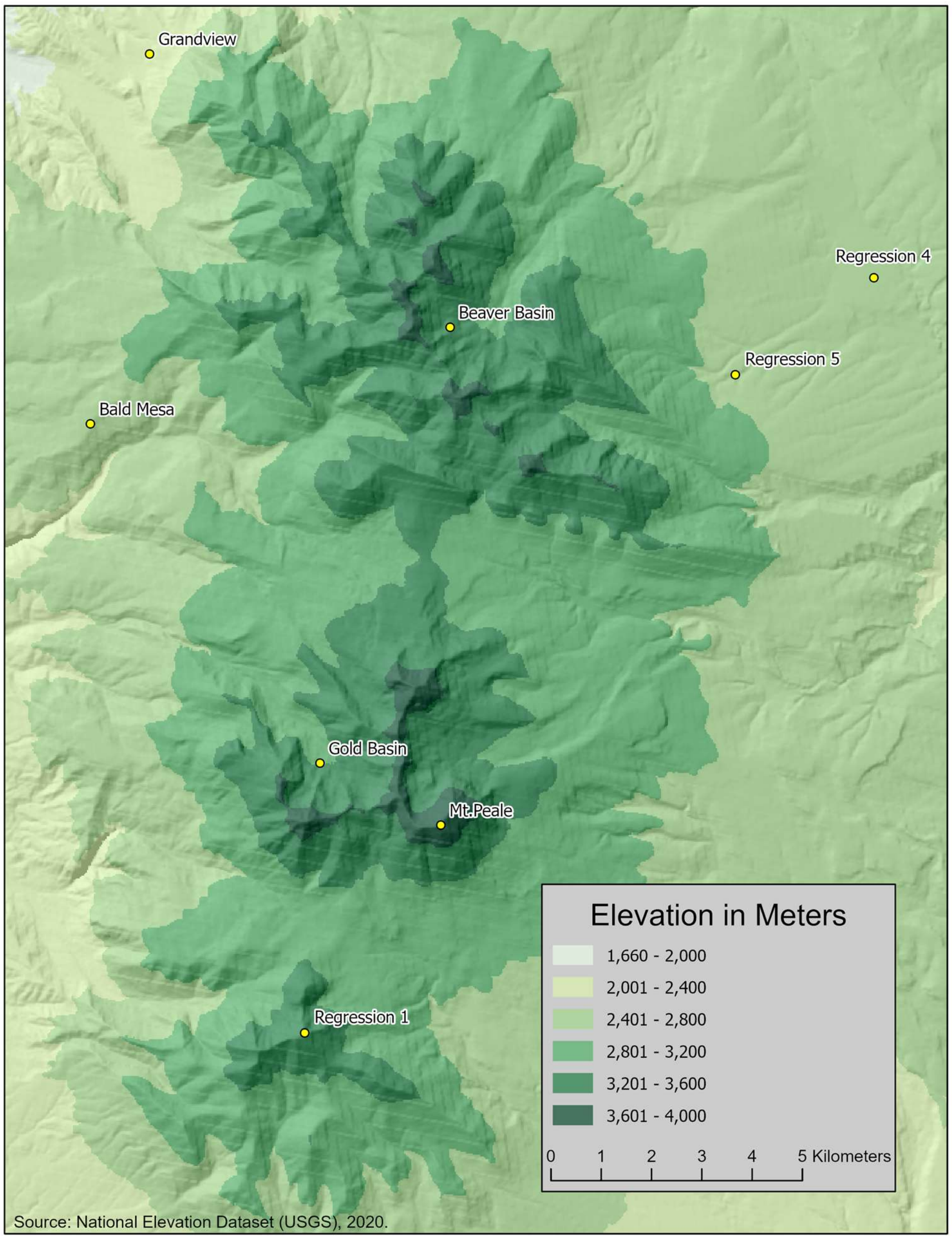

Figure 1: Elevation in the La Sal Mountains.

Table 1: Topographic Characteristics of Data Statistics				
Location	Elev_m	avgtemp_c	Aspect	Slope
Grandview	2204	9.97	258.56	17.56
Hwy 46 La Sal	2317	9.25	161.73	3.72
Brumley Ridge	2354	9.04	334.59	4.03
La Sal Pass Junction	2377	8.92	133.11	3.08
Chicken Creek	2473	7.79	199.31	4.14
Lower Geyser Pass Rd	2503	7.83	233.44	6.74
South Beaver Mesa	2537	6.88	320.65	3.35
Dinosaur Tracks	2598	7.15	52.14	3.97
Bald Mesa	2707	6.53	165.63	1.34
Clark Lake	2863	1.6	2.12	10.39
Boren Mesa	2866	5.04	345.76	8.15
Warner Meadows	2869	4.8	206.46	11.49
La Sal SNOTEL	2918	4.56	30.44	8.69
Wet Fk Mill Cr	2988	2.38	208.51	21.44
Horse Cr	3037	1.24	327.72	4.05
E Mt Peale	3073	2.85	60.04	5.88
La Sal Pass	3091	1.88	101.83	3.28
L. Beaver	3125	1.79	292.32	12.56
Gold Basin	3186	2.04	343.44	8.11
Mellenthin Meadows	3195	1.31	105.97	3.89
Geyser Pass	3207	1.39	240.76	7.31
N Peale RG	3223	1.57	130.37	4.60
Moonlight Meadow	3280	1.7	134.97	7.26
Burro Pass Tr	3329	1.05	98.77	11.00
Beaver Basin	3378	1.17	46.66	18.67
Mt. Mellenthin	3445	0.68	357.43	8.37
Upper Dk Can 2	3512	0.92	169.67	18.74
Regression 1	3576	-1.15	56.80	30.33
Regression 2	2760	5.38	207.36	3.48
Regression 3	2313	8.96	116.43	4.05
Regression 4	2558	6.99	56.93	2.12
Regression 5	2727	5.64	144.12	17.46
Regression 6	3558	-1.04	12.94	42.65
Regression 7	2792	5.12	24.03	6.87
Regression 8	3372	0.48	328.62	9.59
Regression 9	2283	9.19	206.78	4.70
Regression 10	2004	11.42	215.19	5.18
Mt. Peale	3858	-3.4	105.93	29.44

Methodology:

The initial data was a table containing the average annual temperature from 2008 in the La Sal Mountains. The data was collected with a data logger at 28 data stations using a Geographic Coordinate System (GCS). This table was placed into a geodatabase and then exported into a point feature class and given the coordinate system GCS NAD 1983. After making the temperature data table into a point feature class, the point feature class was reprojected into the UTM_NAD_1983 Zone 12N coordinate system, the same one used for elevation. Once temperature and elevation are projected into the right coordinate system, they are then placed on to a map.

Once all these initial steps were completed, the data was interpolated using the Inverse Distance Weighted (IDW) method. IDW uses a set of linearly weighted sample points to determine other cell values. This method never extrapolates the data points, which makes the data more accurate. Distance affects the weight of each sample point since an input data point's attribute value is inversely related to its distance from that grid cell. This interpolation method is best used if the sample points are distributed throughout an area and not clustered. This method shows jagged shapes around the input data locations when data points are clustered, which makes for an unappealing map appearance. There are two parameters for IDW that can alter how the interpolated layer appears. These parameters are power, which allows control of the significance of the input points based on their distance from output grid cells, and number of points, which means you can choose the number of input data points used when determining values for the grid cells. To combat IDW's weakness of jagged shapes around clustered data points, the parameters were changed to a power of six and twelve number of points.

Results:

Looking at the IDW layer, higher temperatures are found at lower elevations. For instance, the data station Grandview has an average temperature of 9.97 degrees Celsius, and it is also at one of the lower elevations of 2,204 meters (Figure 2). The circles represent a concentration of points within a given range; therefore, seeing the circle of red around the 9.97 point indicates that more data points at that lower elevation have higher temperatures. On the other hand, the higher the elevation the colder the temperature as seen with data stations Mt. Peale and Regression 1 with temperatures -3.39 and -1.15 degrees Celsius. Mt. Peale has the highest elevation of 3,858 meters and Regression 1 has the second highest with an elevation of 3,576 meters. There is also a concentration of lower temperatures around the higher elevations, such as around the -3.39 and -1.15 points.

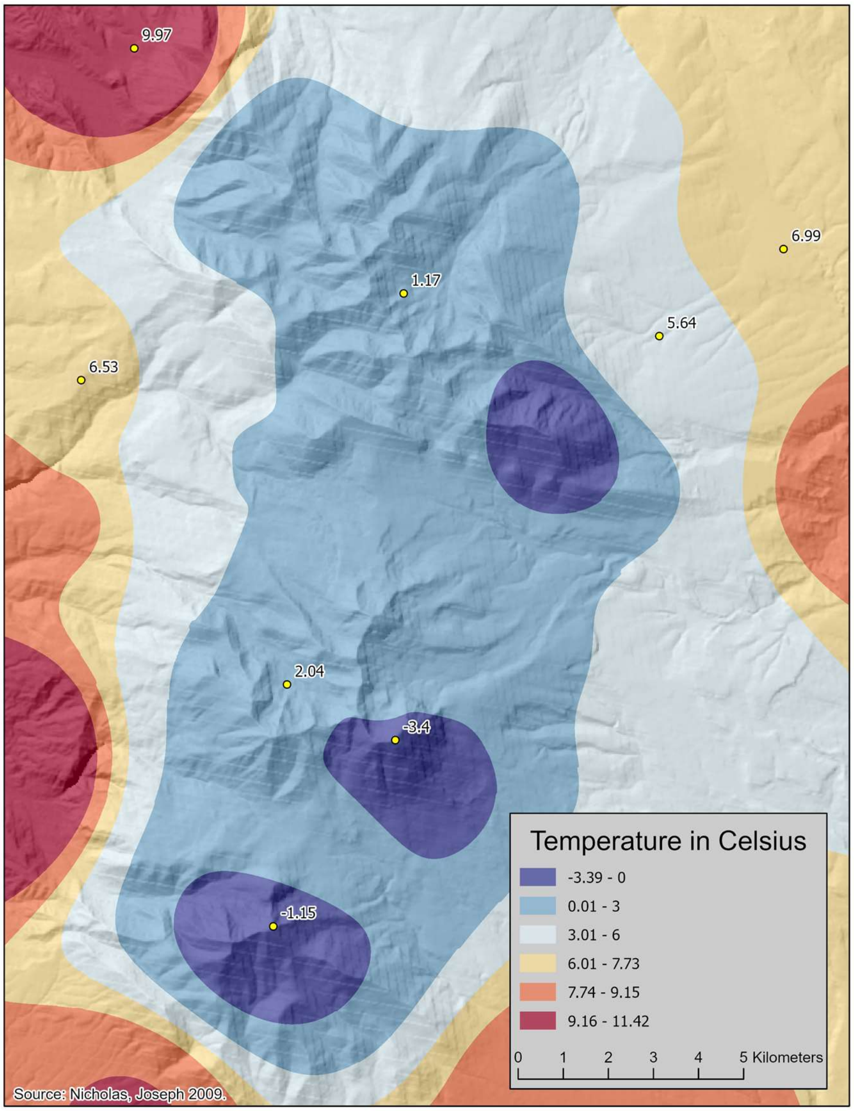

Figure 2: Temperature variations across the La Sal Mountains.

Evaluation of Temperature Model:

The raster model created does not have extrapolated values past the input data points' range of temperature values. The minimum and maximum temperature values are equivalent to the temperature values interpolated. This is a result of using the IDW method since it does not use extrapolation within the data's spatial extent. However, there is extrapolating past the data points' spatial extent since, by definition, corners are extrapolations beyond the data's spatial extent. While a couple corners are cut off due to the orientation of the three-dimensional model (Figure 3), the corners still exist and are, therefore, extrapolations. When looking at the three-dimensional model, it does show the inverse relationship between elevation and temperature. There are a few exceptions to this inverse relationship, for example, the southern slopes of Mt. Peale have a lower elevation but are shown to have cooler temperatures than other mountain peaks with higher elevations. Overall, the IDW method provided a fairly accurate model for showing the relationship between temperature and elevation.

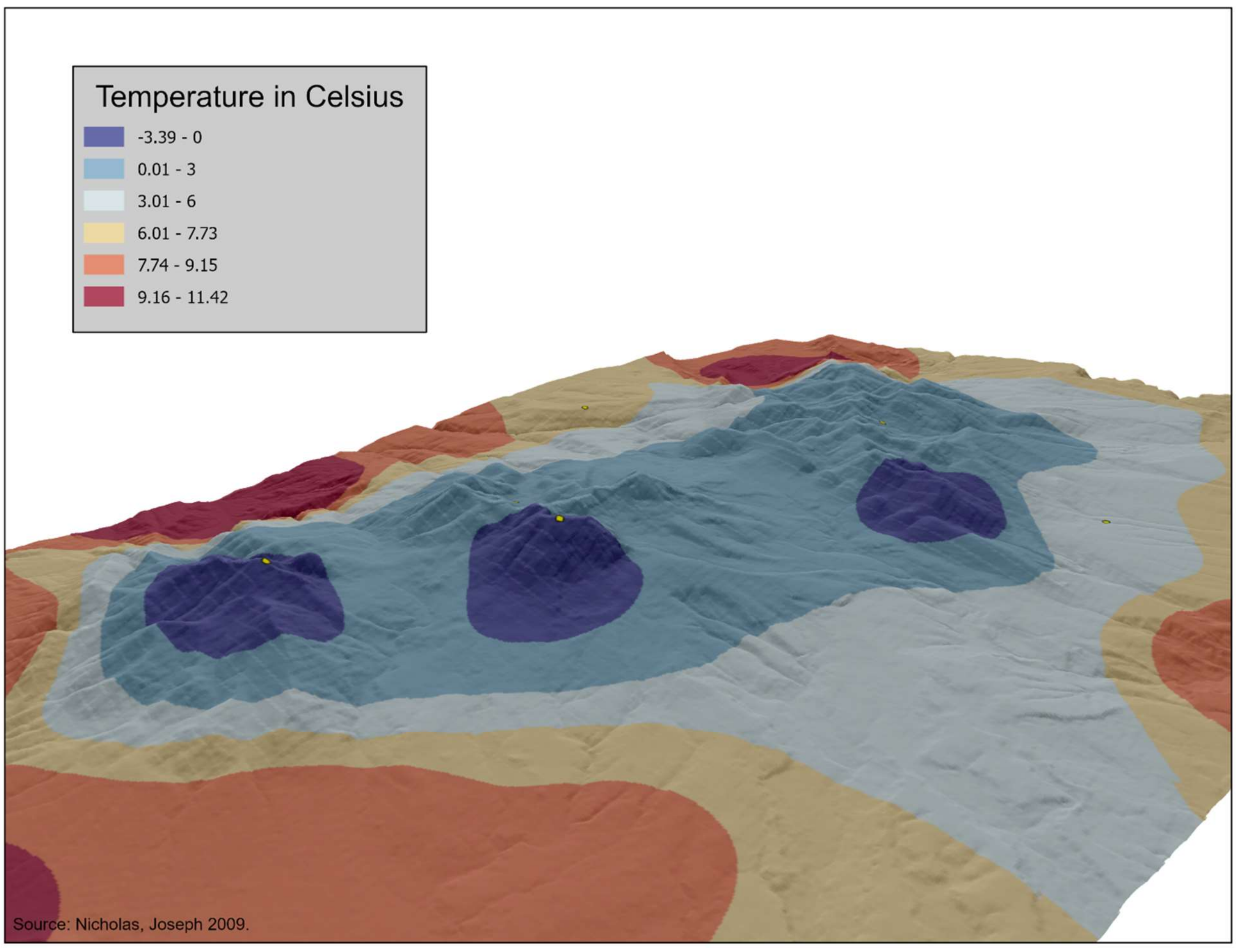

Figure 3: Temperature variations across the La Sal Mountains in three-dimension.