Relationship of Temperature and Topographic Features in the La Sal Mountains Using Spline Interpolation

Introduction

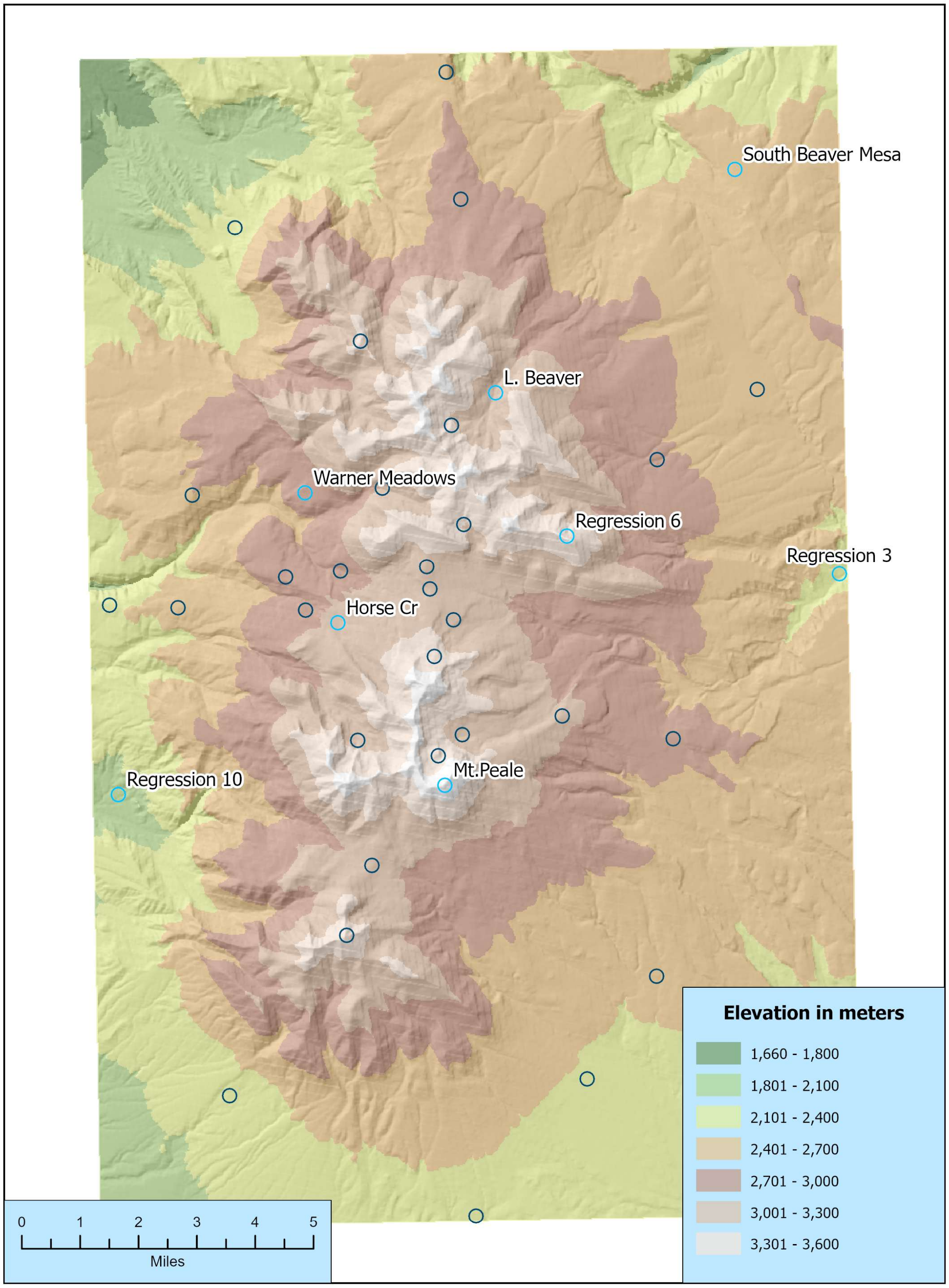
The purpose of this paper is to evaluate an ArcGRID data model of temperature variations for its accuracy in depicting spline interpolation and known topographic relationships. This model is made using temperature and elevation data from Utah's La Sal Mountains. The initial temperature data is from a 2008 study by Dr. Joe Nicholas and is recorded as a vector point feature class showing the average annual temperature in degrees Celsius of thirty-eight randomly distributed data stations and regression points. Elevation data is taken from the United States Geological Survey's National Elevation Dataset from 2020 and is recorded as a floating-point raster file in the NAD 1983 UTM Zone 12N projected coordinate system with a linear unit of meters. The interpolated temperature data is recorded in the same way as the elevation, as a floating-point raster file in the same projected coordinate system and units, with temperature recorded as a z-value attribute.

Describing Topographic Characteristics of Input Temperature Points

The majority of the input temperature points (29) are located on areas of minimal slope, with values between 1.34 and 11.67 meters (see Table 1). There is a singular point recorded at a maximum slope of 42.65 meters. This range and distribution is a fairly accurate representation of the overall area's slope. More areas have low slopes, and the number of points decrease as the slope increases, though the actual range of slope values is more inclusive, with true minimum and maximum values of 0.00 meters and 68.98 meters respectively.

The input temperature points' aspect ranges from 2.12 and 357.43 degrees, with the highest concentration of points (12) being on the southeast aspect. Eight of those southeastern points occur between 90.9 and 135.4 degrees (see Table 1). The actual aspects of the La Sal mountain range is much more evenly distributed between 0 and 360 degrees, with a slightly higher number of slopes facing the east (between 56.2 and 101.2 degrees) and southwest (between 202.5 and 258.7 degrees).

The input temperature points' elevation ranges from 2,004 and 3,858 meters above sea level, with the highest concentration of points (8 each) being between 2,699.3 and 2,931 meters high and 3,162.8 and 3,394.5 meters high (see Figure 1 and Table 1). This is roughly accurate, as it follows the bell-shape curve of the actual elevation values, though it underrepresents the number of values between 2,931 and 3,162.8 meters. This input range also completely lacks points from between 1,658.8 and 2,004 meters and between 3,858 and 3,875.1 meters, which are the lowest and highest actual elevation values.



Source: National Elevation Dataset (USGS), 2020

Figure 1: Elevation of the La Sal Mountains

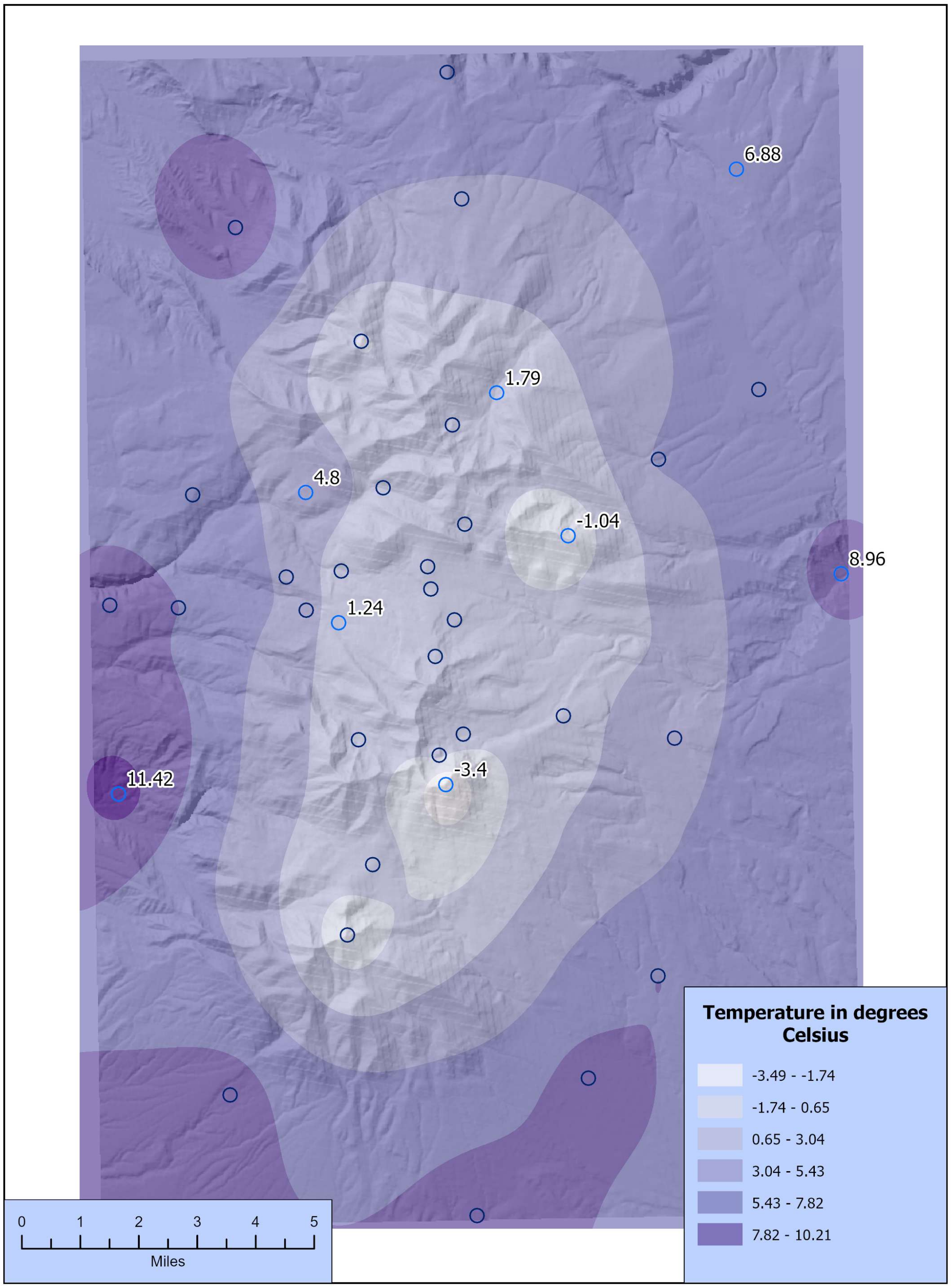
Table 1: Topographic Characteristics of Data Stations				
Site	Elevation (m)	Average Temp (C)	Slope	Aspect
Grandview	2204	9.97	17.5573158	258.5636902
Hwy 46 La Sal	2317	9.25	3.7165833	161.7328033
Brumley Ridge	2354	9.04	4.031549	334.5887146
La Sal Pass Junction	2377	8.92	3.0847082	133.1055756
Chicken Creek	2473	7.79	4.1418095	199.3132324
Lower Geyser Pass Rd	2503	7.83	6.7378902	233.4437256
South Beaver Mesa	2537	6.88	3.3502026	320.6503601
Dinosaur Tracks	2598	7.15	3.9737763	52.1421013
Bald Mesa	2707	6.53	1.3419079	165.6316223
Clark Lake	2863	1.6	10.3869104	2.1186666
Boren Mesa	2866	5.04	8.1494169	345.7615051
Warner Meadows	2869	4.8	11.4890738	206.4555969
La Sal SNOTEL	2918	4.56	8.6873465	30.4363346
Wet Fk Mill Cr	2988	2.38	21.4404278	208.5070953
Horse Cr	3037	1.24	4.0483565	327.7210999
E Mt Peale	3073	2.85	5.8816948	60.0423889
La Sal Pass	3091	1.88	3.2831762	101.8347168
L. Beaver	3125	1.79	12.5632162	292.3205566
Gold Basin	3186	2.04	8.1141615	343.4389038
Mellenthin Meadows	3195	1.31	3.8918104	105.9691772
Geyser Pass	3207	1.39	7.3142967	240.76297
N Peale RG	3223	1.57	4.5993576	130.3712769
Moonlight Meadow	3280	1.7	7.2570763	134.9659119
Burro Pass Tr	3329	1.05	10.996069	98.766777
Beaver Basin	3378	1.17	18.6656227	46.6584206
Mt Mellenthin	3445	0.68	8.3696117	357.427887
Upper Dk Can 2	3512	0.92	18.7410069	169.6652527
Regression 1	3576	-1.15	30.3264904	56.7956772
Regression 2	2760	5.38	3.4783936	207.361618
Regression 3	2313	8.96	4.0468316	116.4331665
Regression 4	2558	6.99	2.1177859	56.9297523
Regression 5	2727	5.64	17.4600868	144.1210938
Regression 6	3558	-1.04	42.6540833	12.943532
Regression 7	2792	5.12	6.8650918	24.0284309
Regression 8	3372	0.48	9.586031	328.6152039
Regression 9	2283	9.19	4.6952343	206.7830505
Regression 10	2004	11.42	5.1781235	215.1889496
Mt.Peale	3858	-3.4	29.4411373	105.9264145

Description of Interpolation Method

The input data geodatabase table containing average annual temperatures of data stations in the NAD 1983 geographic coordinate system has been transformed into a point feature class and reprojected in the NAD 1983 UTM Zone 12N projected coordinate system. This feature class has then been interpolated into a raster temperature layer of the same projections using the spline interpolation method. The settings for the spline method have been changed to tension-type, with a weight of 220 and a point consideration of 4 to minimize extrapolation error in temperature values. This results in a temperature range of -3.49 to 11.42 degrees Celsius, which is extremely close to the actual temperature range of -3.4 to 11.42 degrees Celsius.

Description of Temperature Variations

Based on this ArcGRID model, elevation has an inverse effect on temperature values. Raster cells representing lower temperatures are located at areas of higher elevation, such as the peak of Mt. Peale, which has the lowest recorded temperature of -3.4 (see Table 1, Figure 2). Raster cells representing higher temperatures are located at areas of lowest elevation, such as Regression point 10, which has the highest recorded temperature of 11.42 degrees Celsius (see Table 1, Figure 2).



Source: Nicholas, Joseph 2009.

Figure 2: Temperature Variation across the La Sal Mountains

Evaluation of Temperature Model

This floating-point raster model corresponds to the original temperature data, in that it does not extrapolate far beyond the data's range or spatial extent. There is minimal extrapolation of the lowest temperature values, with a difference of less than 1/10th of a degree.

This model does show that elevation has an inverse effect on temperature values. This means that higher temperatures typically occur at places of lower elevation and vice versa, though there are some exceptions at the middle elevations and temperatures recorded in the range of -1.74 to 3.04 degrees Celsius where increases and decreases are concurrent (see Figure 3). This is likely due to variations in aspect and slope, as recorded in Table 1, which can affect how temperature is absorbed and reflected based on the sun's position relative to the earth.

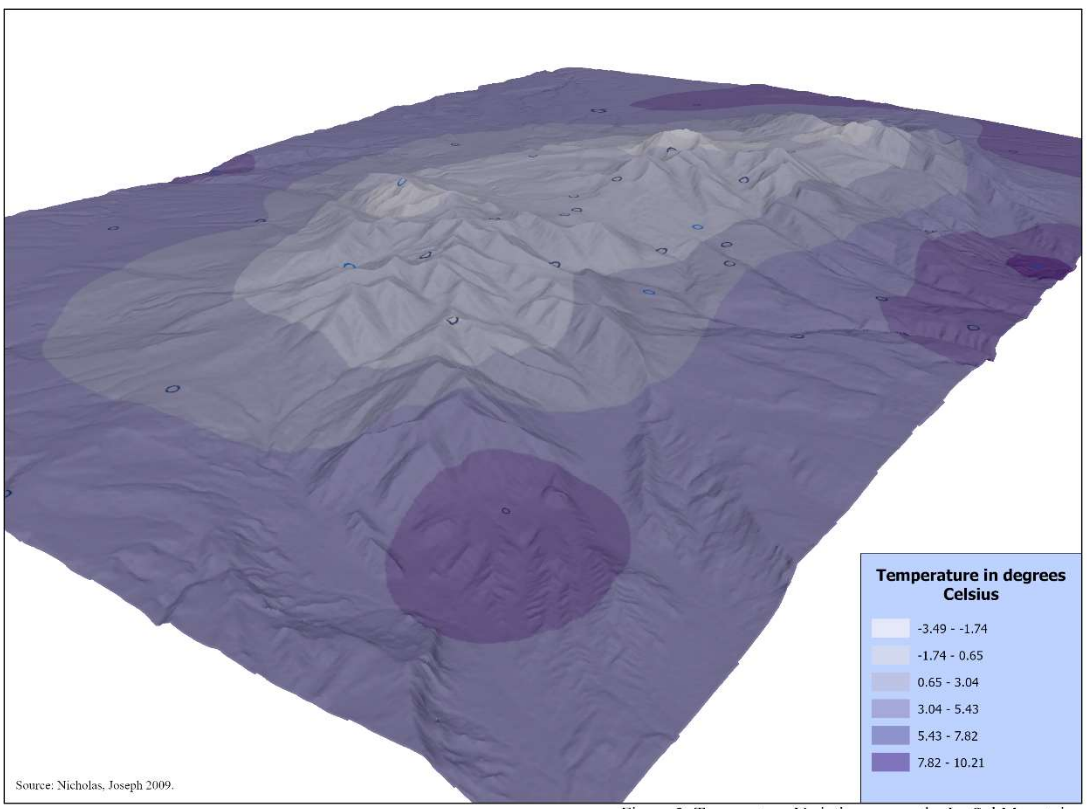


Figure 3: Temperature Variation across the La Sal Mountains

Overall, this raster temperature surface adequately models a basic relationship between temperature and elevation. There are likely some minor errors with extrapolation at lower temperature values but are to such a small degree that they should be largely inconsequential. The effects of previously noted variations in aspect and slope have not been fully explored, but likely account for irregular relationships between temperature and elevation, so this model could be improved by further analyzing how these attributes affect temperature in addition to elevation.