Evaluation of 2-Meter Temperature Surveys from the Coso Geothermal Field, CA

Jade Zimmerman, Kelly Blake, Stephanie Nale, Andrew Sabin, and Wei-Chuang Huang

Navy Geothermal Program Office, 429 E. Bowen Road, China Lake, CA 93555, USA

Keywords

2-meter temperature survey, Coso geothermal field, exploration

ABSTRACT

In September 1977, LeSchack and Lewis carried out a 2-meter temperature probe (2mtp) survey at the Coso Geothermal Field (CGF) with results published in a 1983 *Geophysics* paper. The Navy Geothermal Program Office (GPO) set out to replicate this survey to determine if heat anomaly signatures had changed over time. The GPO 2mtp survey was collected in 3 phases between summer 2019 and fall 2020, primarily due to the Covid-19 pandemic. Following this survey, GPO also collected seasonal 2mtp measurements from September 2021 to November 2022. The combination of information ultimately led to a process of data correction and normalization in order for the GPO 3-phase survey to be compared to the LeSchack and Lewis survey. On average, the GPO data are ~0.68°C warmer than the LeSchack and Lewis data. Overall, the difference between the LeSchack and Lewis survey and the GPO survey showed a slight decrease in temperature east of Sugarloaf in the Main Flank near the Navy I power plant and an increase in the southern Main Flank between the BLM East and BLM West power plants while a heat anomaly present in the East Flank was apparent in both surveys. When both 2mtp surveys are compared to the existing downhole static temperature data, the LeSchack and Lewis survey generally matches the downhole temperatures collected prior to geothermal production. However, recent downhole static temperatures, collected between 1995 and 2007, show a heat anomaly near the center of the geothermal field, southeast of Sugarloaf, which is not apparent in the recent GPO 2mtp survey. In addition, the north-northwestern area of the field shows an increase in temperature according to the comparison between the LeSchack and Lewis and GPO 2mtp surveys. However, there are no wells in this area to assist in explaining this change and therefore, more analysis is needed.

1. Introduction

Shallow temperature (1-2 m) surveys have been used to detect geothermal anomalies beginning around 1956 with a study by Kintzinger of hot ground near Lordsburg, NM. Since then, the tools, overall collection process, and data corrections have been refined (e.g. Noble and Ojiambo, 1975; Olmsted, 1977; Trexler et al., 1982; LeSchack and Lewis, 1983; Coolbaugh et al., 2007; Sladek et al., 2007; Sladek and Coolbaugh, 2013; Coolbaugh et al., 2014). A typical 2mtp survey in the Basin and Range consists of hammering 2 m long 14 mm diameter steel probes into the ground and inserting a Pt RTD (Resistance Temperature Detector) into each probe. The RTDs are given time to equilibrate (about an hour) then the temperatures at 0.5 m, 1 m, and 2 m are obtained (Coolbaugh et al., 2007; Sladek et al., 2007).

LeSchack and Lewis, 1983 carried out the first 2-meter temperature probe (2mtp) survey at the Coso Geothermal Field (CGF) in September 1977. The CGF is located in the Mojave Desert in southern California within the boundary of Naval Air Weapons Station China Lake. The goal of this 1983 study was to develop a technique for using shallow temperature surveys for geothermal reconnaissance and exploration. In their 1983 study, LeSchack and Lewis collected 102 2mtp point measurements in and around the CGF (Fig. 1). Criteria for selecting point locations included road access and confirmation of a geothermal anomaly from previous drilling.

The Navy Geothermal Program Office (GPO) formed in 1978 and was tasked with management and oversight of the resource at the CGF. Understanding how the CGF has changed over time is an important part of managing the resource. This is what motivated GPO to reproduce the LeSchack and Lewis 2mtp survey as closely as possible in 2019. GPO collected 133 points as close as possible to the LeSchack and Lewis points (Fig. 1). However, many roads have changed or have become impassable with time, so some points required relocation. To fill in data gaps in the LeSchack and Lewis survey, GPO added extra points, primarily in the northwest and eastern areas of the CGF. The GPO survey was carried out in 3 phases spanning from summer 2019 to fall 2020, making seasonal variations within the GPO data a concern. Seasonal 2mtp data were collected between September 2021 and November 2022. Ultimately, it was decided that the best approach for making a relative comparison between the two surveys was to normalize the datasets using an approached described by Sladek and Coolbaugh (2013) where the 2m temperatures are normalized to a background temperature. This approach provided an alternative to making seasonal corrections as well as correcting for other shallow temperature influences. The background temperature used for the GPO and LeSchack and Lewis surveys is 26.38ºC.

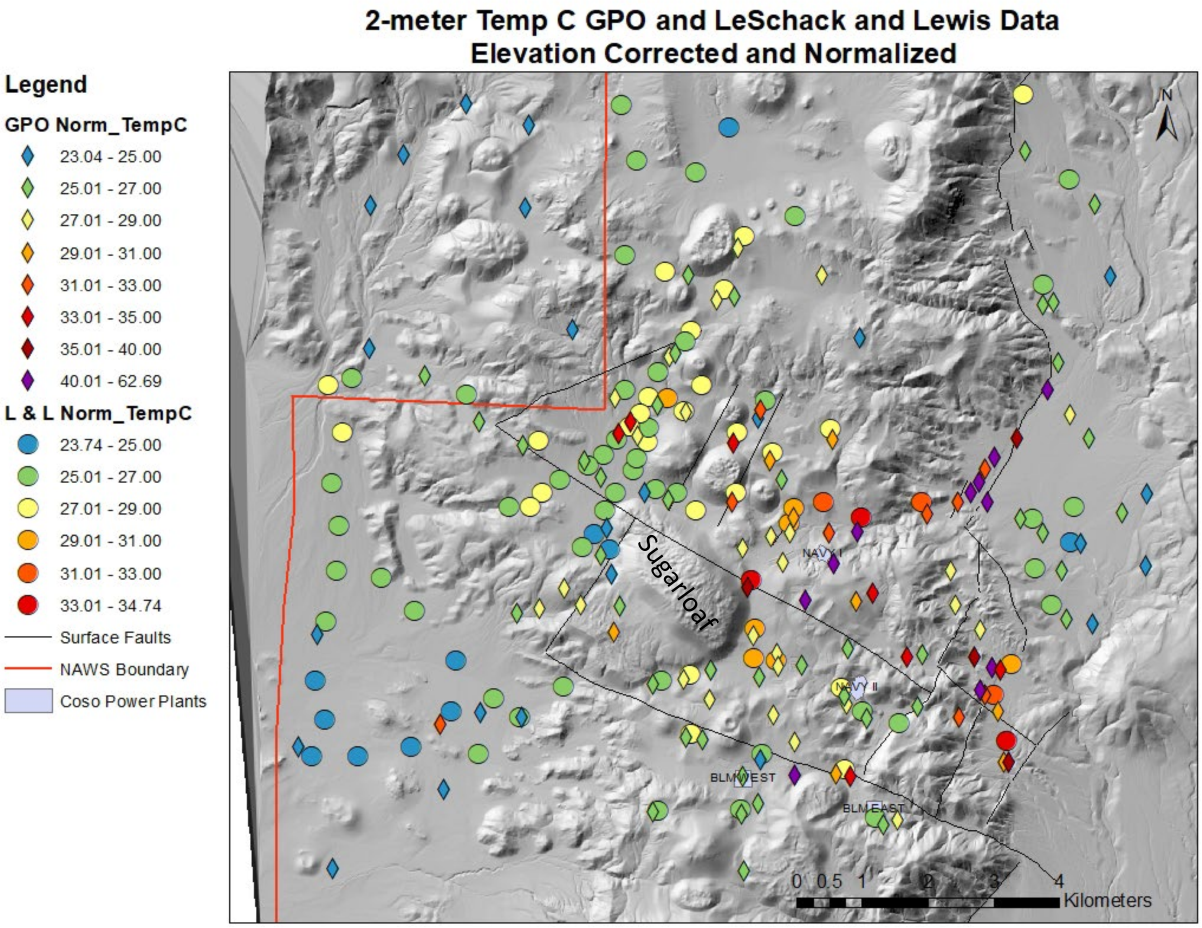


Figure 1: Map of the CGF showing the locations of the LeSchack and Lewis 2mtp survey (circles) and the GPO 2mtp survey (diamonds). Color ramp represents 2m temperatures that have been corrected for elevation then normalized to a 26.38ºC background temperature.

2. Methods

To make a relative comparison between the GPO 2mtp survey and the LeSchack and Lewis 2mtp survey, the GPO 2 m temperature data would need to be corrected for seasonal variation at minimum since data collection covered two seasons and was acquired in 3 phases over the course of more than a year. The 2 m temperatures reported by LeSchack and Lewis, 1983 were corrected for elevation after finding that a significant negative correlation existed between temperature and elevation. Using the adiabatic lapse rate of −1.0ºC/100 m elevation change, LeSchack and Lewis corrected the 2 m temperature data to an arbitrarily chosen datum of 1036.3 m. Because of this, the GPO 2 m temperature data were first corrected to the same datum. Like the LeSchack and Lewis survey, GPO made every attempt to place probes such that slope of the terrain was close to zero and therefore unnecessary to correct for later. GPO also performed an albedo correction on the data, but the correlation was weak. In addition, the reported LeSchack and Lewis 2 m temperature data was not corrected for albedo. Therefore, it was determined that an albedo correction was neither sufficient nor necessary. From this point, the remaining concerns for the relative comparison were the seasonal variation within the GPO 2mtp dataset and the seasonal and temporal difference from the LeSchack and Lewis 2mtp dataset. Though the GPO collected seasonal data for over a year, the decision was made to normalize the datasets, which would account for both the seasonal and temporal changes between GPO and LeSchack and Lewis 2mtp surveys (Sladek and Coolbaugh, 2013).

3. Seasonal Data

The best time of year to conduct 2mtp surveys is late summer to fall (Sladek et al., 2012). The GPO 2mtp survey was collected during summer and fall, but it required more than a year to collect. This prompted GPO to study seasonal 2mtp variations at the CGF with the initial intent of using that information to correct the 2mtp survey for seasonal changes. What we learned from the seasonal survey was that the same seasons from different years could vary by as much as 9ºC with an average of 4ºC (Table 1).

Point	**Diff**	**Seasons**	**Stats**
13	-4.16	Fall21-Fall22	Stdev
22	-3.72	Fall21-Fall22	1.72
23	-4.88	Fall21-Fall22	
27	-4.55	Fall21-Fall22	Mean
28	-4.77	Fall21-Fall22	-4.33
30	-5.22	Fall21-Fall22	
44	-2.33	Fall21-Fall22	
46	-1.33	Fall21-Fall22	
48	-9.16	Fall21-Fall22	
50	-5.5	Fall21-Fall22	
63	-4.83	Fall21-Fall22	
71	-4.72	Fall21-Fall22	
74	-4.05	Fall21-Fall22	
87	-2.5	Fall21-Fall22	
89	-3.27	Fall21-Fall22	

Table 1: Data showing the difference between 2-meter temperature measurements taken at the same point during the same season, one year apart along with the standard deviation and mean of the data.

Not surprisingly, the largest average difference in seasons is between winter and summer at about 11ºC with the smallest average difference being between spring and fall at about 2ºC (Table 2).

Average Variations 2022	
Spring22-Summer22	-6.8
Summer22-Fall22	4.16
Winter22-Spring22	-4.77
Winter22-Summer22	-11.17
Winter22-Fall22	-6.39
Spring22-Fall22	-1.96

Table 2: Average seasonal variations for 2mtp measurements collected in 2022.

The results of the seasonal data collection for each point measured are shown in Figure 2. The anomalously hot temperatures measured at points 28 and 89 were located in an area containing fumaroles. For fitting a curve to the data, point 46 was also removed for its high temperature readings. Two functions were fit to the data: a polynomial and a sine function, both with acceptable *R*-squared values (Fig. 3).

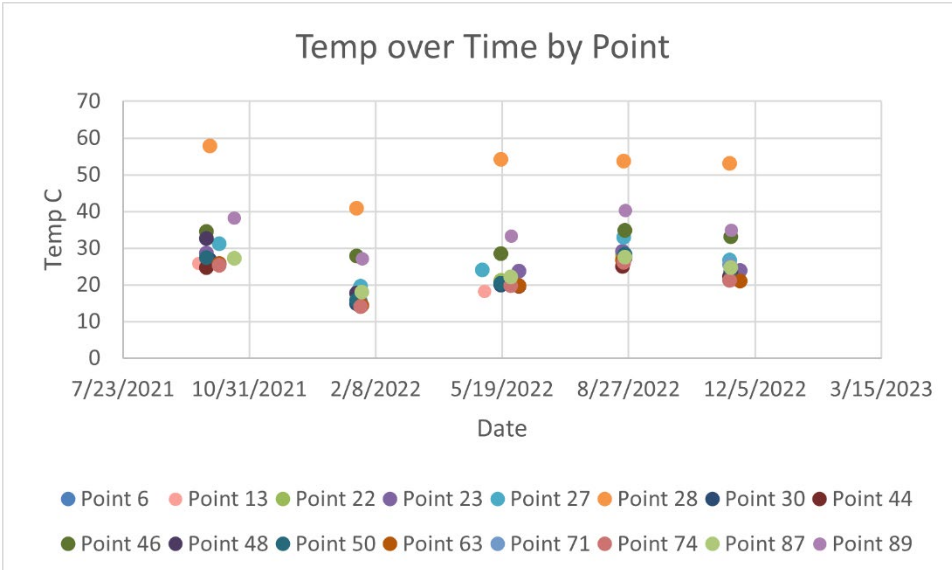
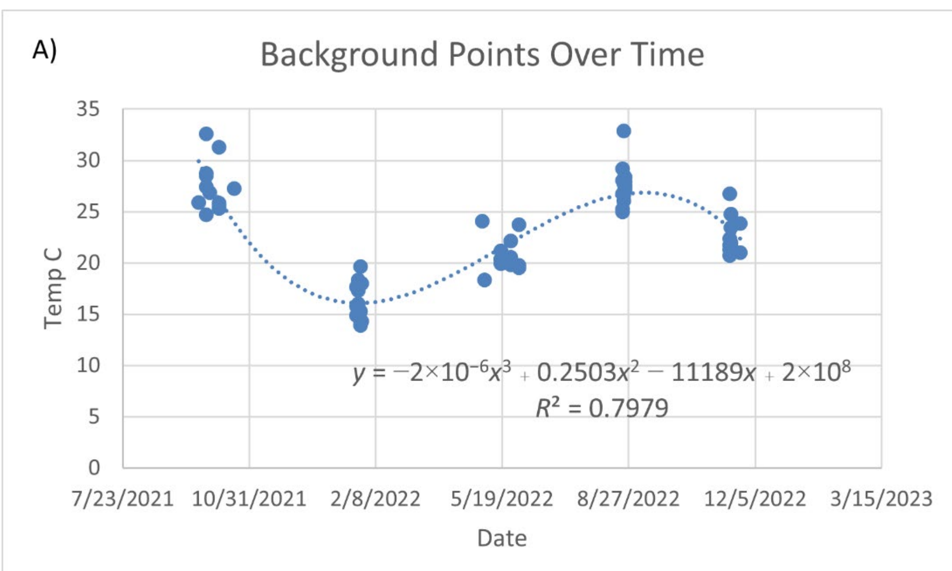


Figure 2: Temperatures for all points measured during the seasonal analysis in degrees Celsius over time. Points 28, 89, and 46 are hotter than the rest of the points measured, with point 28 being the hottest due to its proximity to a fumarole.



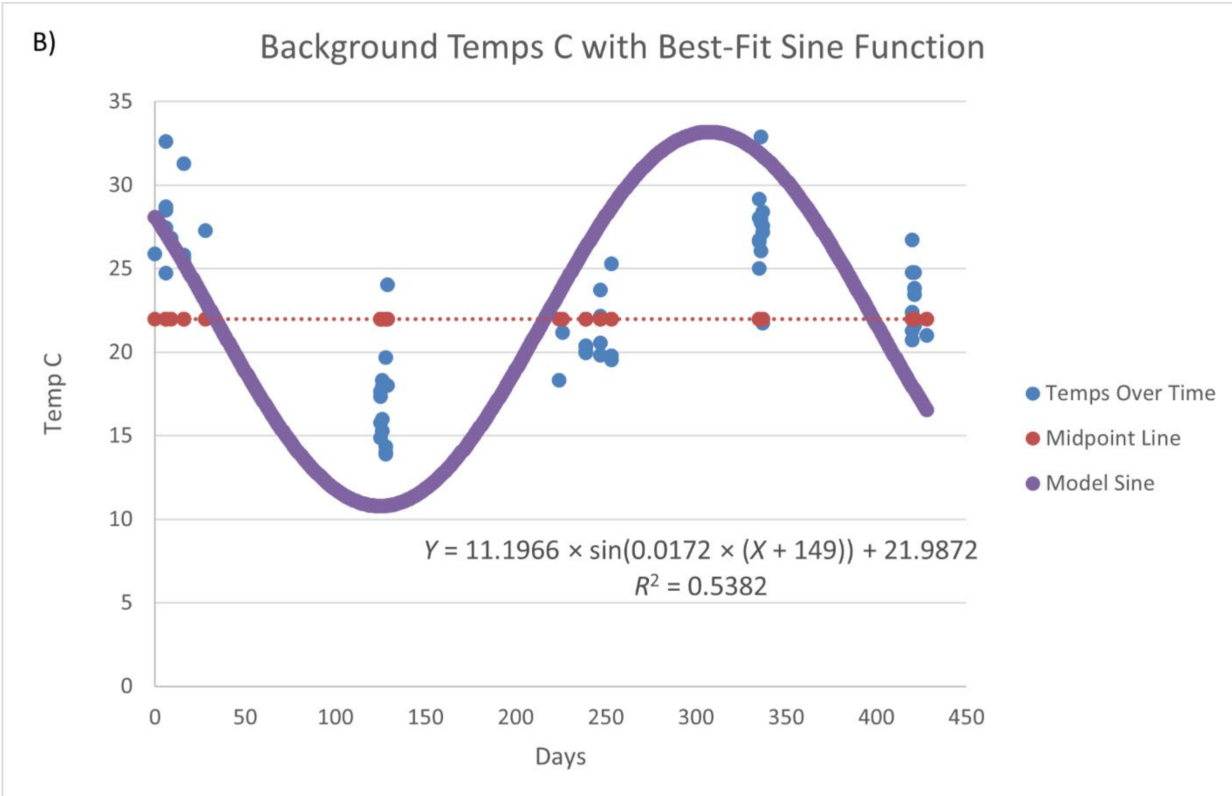


Figure 3: A) Graph of the cooler seasonal 2-meter temperatures over time in degrees Celsius with a best-fit polynomial function and associated R^2 value of 0.7979. B) Graph of the cooler seasonal 2-meter temperatures over time in degrees Celsius with a best-fit sine function and associated R^2 value of 0.5382.

Steps have also been taken to use a non-linear least squares solver using SciPy tools to find the best function to fit the data. Regardless of model function used, additional seasonal data would improve them.

4. Elevation Correction

As mentioned above, the GPO 2mtp data were corrected for elevation in order to meet the same correction standards as the data reported by LeSchack and Lewis, 1983 in order to obtain a reasonable comparison between the two datasets. The GPO data were corrected to the same arbitrary datum used by LeSchack and Lewis of 1036.3 m using the adiabatic lapse rate of −1.0ºC/100 m elevation change. Outliers from each of the 3 phases of GPO 2mtp data were removed based on the z-score test method. Then, the elevation correction for each point was determined by the following equation

$$Yt = (1036.3\text{m} - Xz)(-1°\text{C}/100\text{m}) \quad (1)$$

Where Yt is the elevation correction factor and Xz is the elevation of each 2mtp point.

5. Normalization of Datasets

The final step before comparing the LeSchack and Lewis data to the GPO data was to normalize both datasets. The method used was presented in Sladek and Coolbaugh, 2013 and involves normalizing the values to a background temperature so that relative comparisons can be made and provides an alternative to making seasonal corrections, which was determined to be ideal until GPO can collect more seasonal data to improve the models. To determine the mean background temperature for CGF, both the LeSchack and Lewis data and the GPO data were plotted by increasing temperature (Fig.4). All of the temperatures less than 35.028ºC were used to calculate the mean background temperature of 26.38ºC.

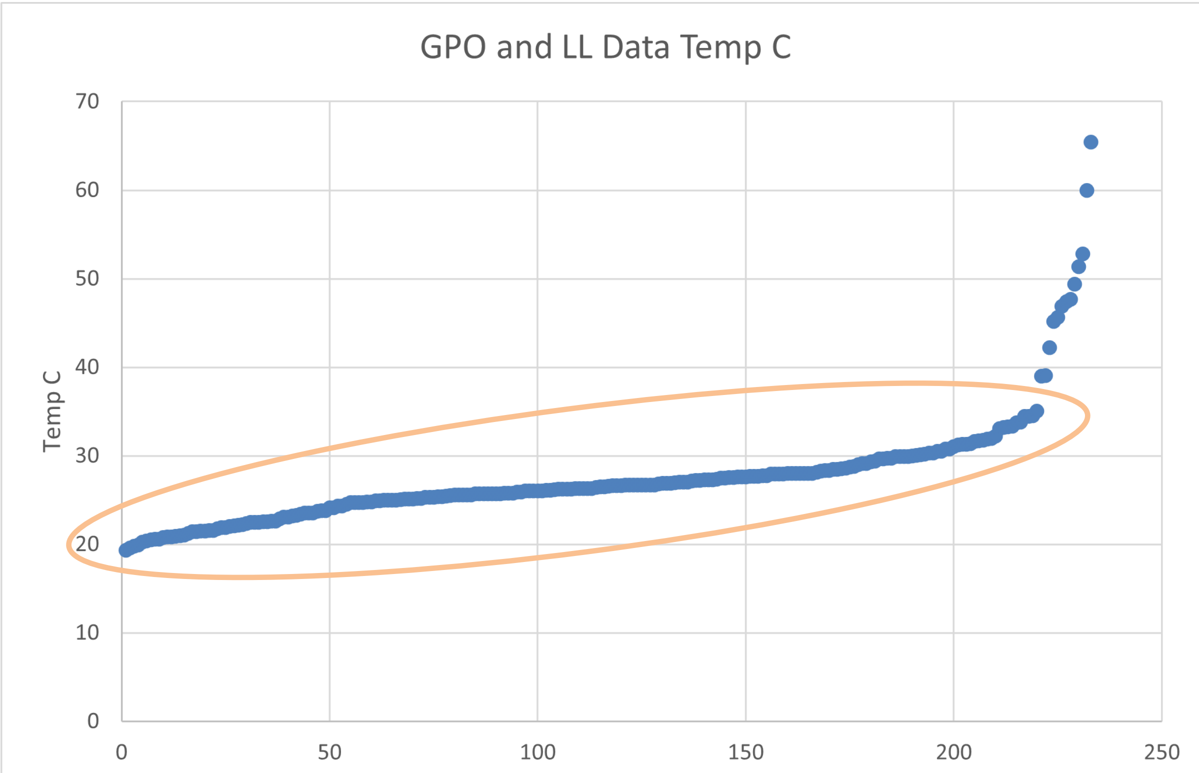


Figure 4: Graph of GPO and LeSchack and Lewis elevation corrected 2mtp data by increasing temperature. The orange oval is highlighting the background temperatures, while the values outside the oval represent thermal anomalies.

The next step is to calculate the mean background temperature of each phase of data collection, including the LeSchack and Lewis data. Graphs like the one in Figure 4 were made for each phase of GPO data collection and the LeSchack and Lewis data in order to estimate the background temperature of each dataset (Fig. 5). The normalization factor for each phase is determined by the equation

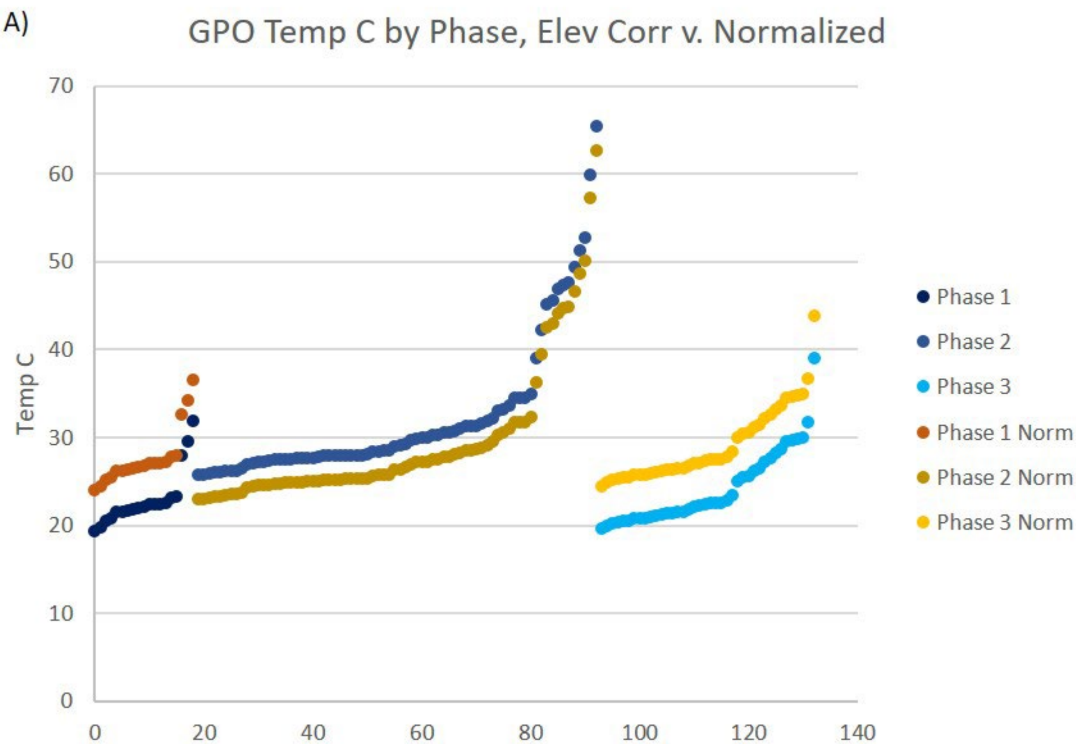
$$N = Bt - Bpt \qquad (2)$$

Where N is the normalization factor (or correction factor) for each phase, Bt is the overall mean background temperature of all of the phases combined (26.38ºC), and Bpt is the mean background temp of each phase. The values for Bpt and N are shown in Table 3. For GPO phase 3, the background is considered to be all temperatures less than the first inflection, or sudden increase in temperature, in the dataset seen in Figure 5A (< 23.43ºC). The value N is then added to each elevation corrected temperature within that phase to obtain the normalized temperature in degrees Celsius.

Phase	Background TempC Range	*Bpt*	*N*
GPO1	19.33 to 23.3	21.73	4.65
GPO2	25.745 to 35.03	29.09	-2.71
GPO3	19.58 to 23.43	21.43	4.95
L&L	23.1 to 27.00	25.64	0.74

Table 3: Mean background temperatures of each phase (*Bpt*) along with the normalization factor (*N*).

A)



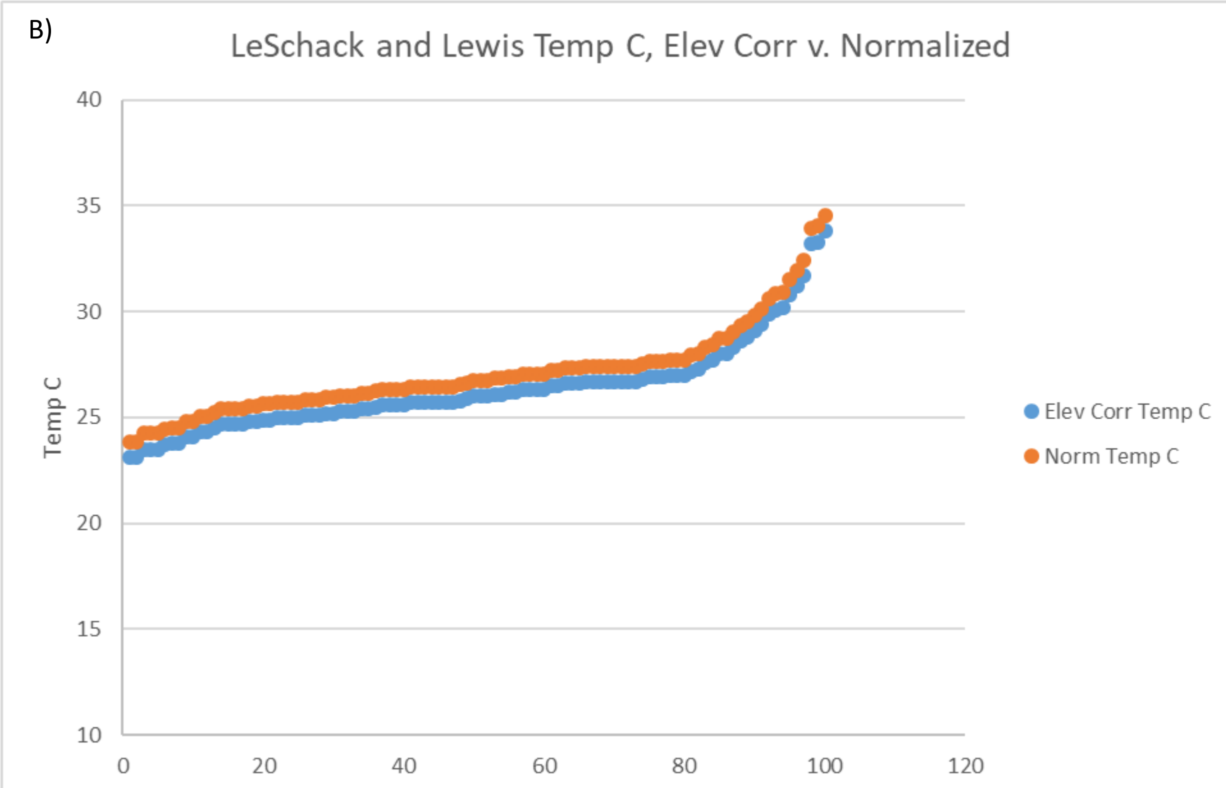
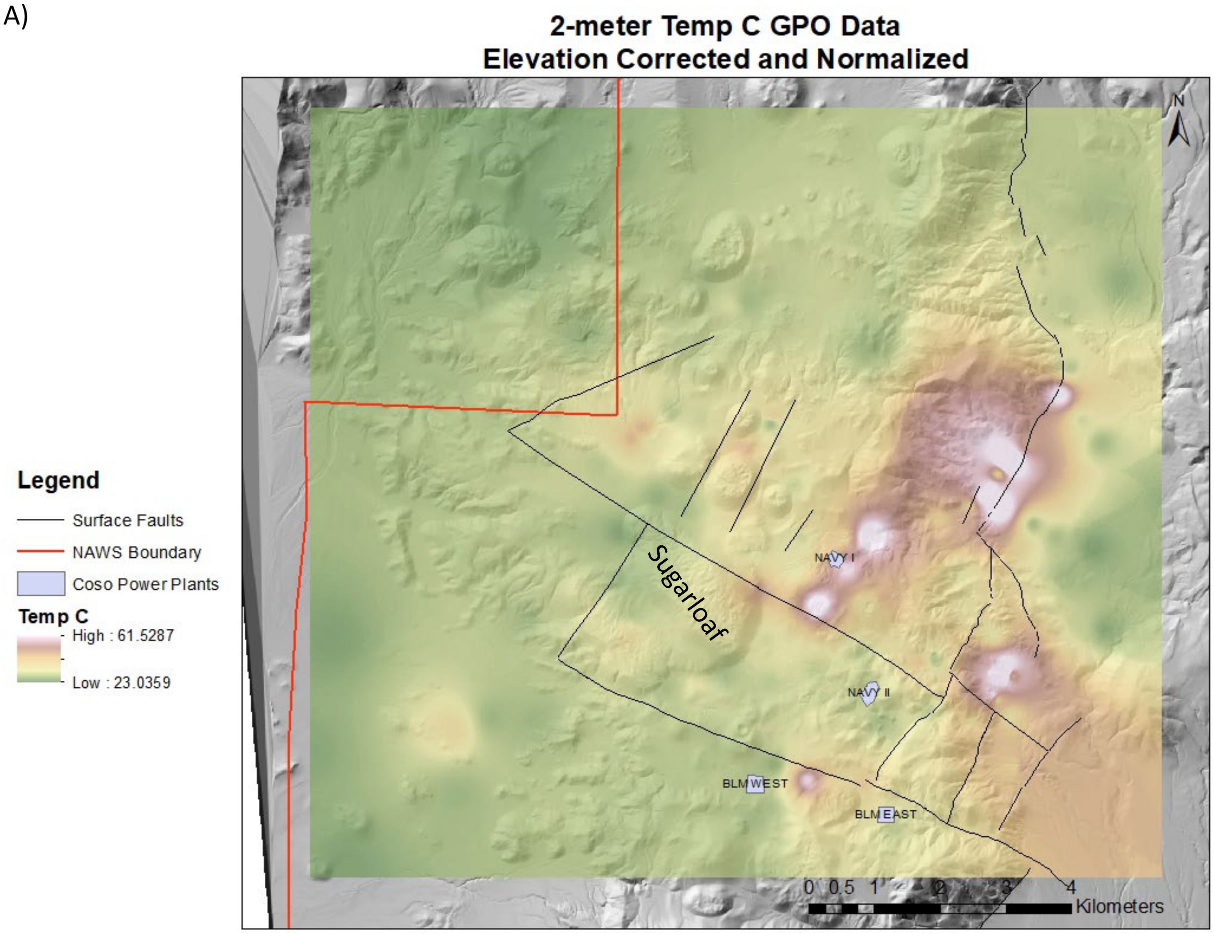


Figure 5: A) Graph of each phase of GPO 2mtp data by increasing temperature in Celsius. From left to right is phase 1, phase 2, and phase 3 displayed with increasing temperatures. Elevation corrected datasets are in shades of blue, while their normalized counterparts are in shades of orange. B) Graph of LeSchack and Lewis elevation corrected 2mtp data (blue) and normalized data (orange) by increasing temperature in Celsius.

The results of applying the normalization factor to each phase were first visualized in ArcGIS® using the inverse distance weighted interpolation (Fig. 6). These maps are not colored on the same scale in order to emphasize where the heat anomalies are located. In general, both maps show heat anomalies around Navy I, and east of the Navy II plants (East Flank).

A)


2-meter Temp C GPO Data
Elevation Corrected and Normalized
Legend
Surface Faults
NAWS Boundary
Coso Power Plants
Temp C
High : 61.5287
Low : 23.0359
Sugarloaf
NAVY I
NAVY II
BLM WEST
BLM EAST
0 0.5 1 2 3 4
Kilometers
N

B)

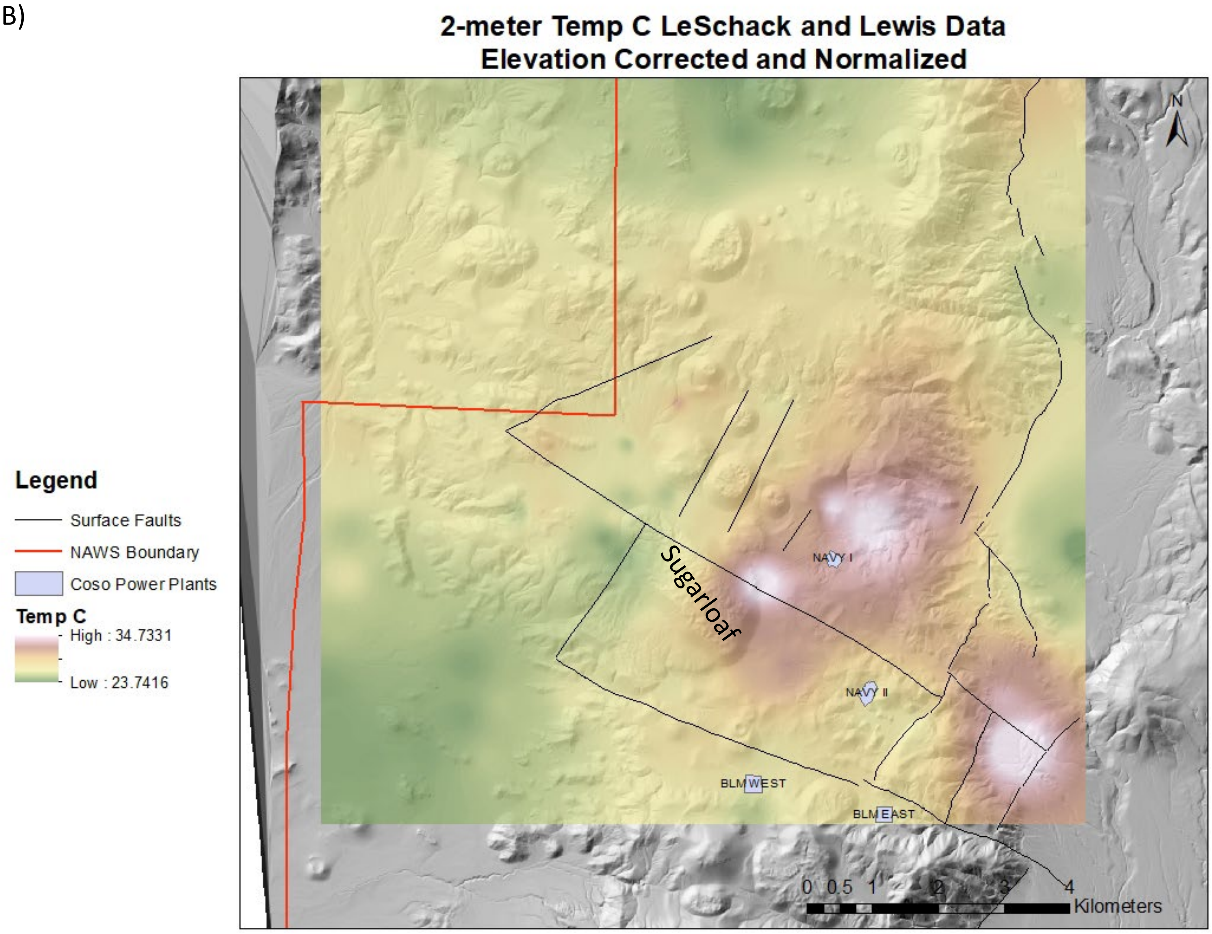
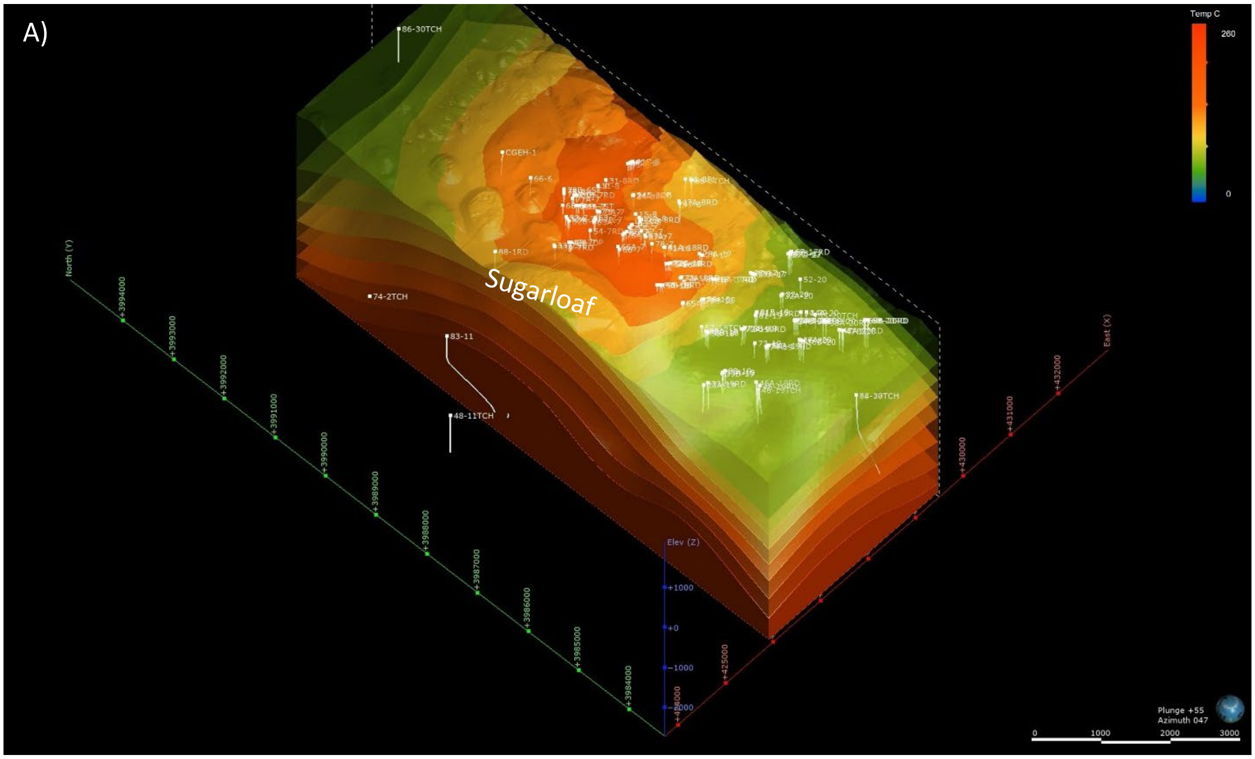


Figure 6: A) A map of the GPO 2mtp data after the data were elevation corrected and normalized. B) A map of the LeSchack and Lewis 2mtp data after the reported elevation corrected data was normalized. Both maps are colored by temperature in degrees Celsius. The maps are not colored on the same scale in order to better visualize the location of heat anomalies.

To check that these heat anomaly maps are reasonable, they were compared to the downhole temperature data available, which was modeled using the radial basis function interpolation in Leapfrog®. The LeSchack and Lewis 2mtp data were collected prior to start-up of the geothermal plant at Coso. Therefore, only pre-start-up downhole static temperatures collected after drilling were used in the model (Fig. 7A). Conversely, the GPO 2mtp data were collected after start-up of the Coso geothermal plant, so only the post-start-up downhole temperatures were used in the model (Fig. 7B).


A)
Sugarloaf
Temp C
260
0
North (Y)
East (X)
Elev (Z)
Plunge +55
Azimuth 047
0
1000
2000
3000

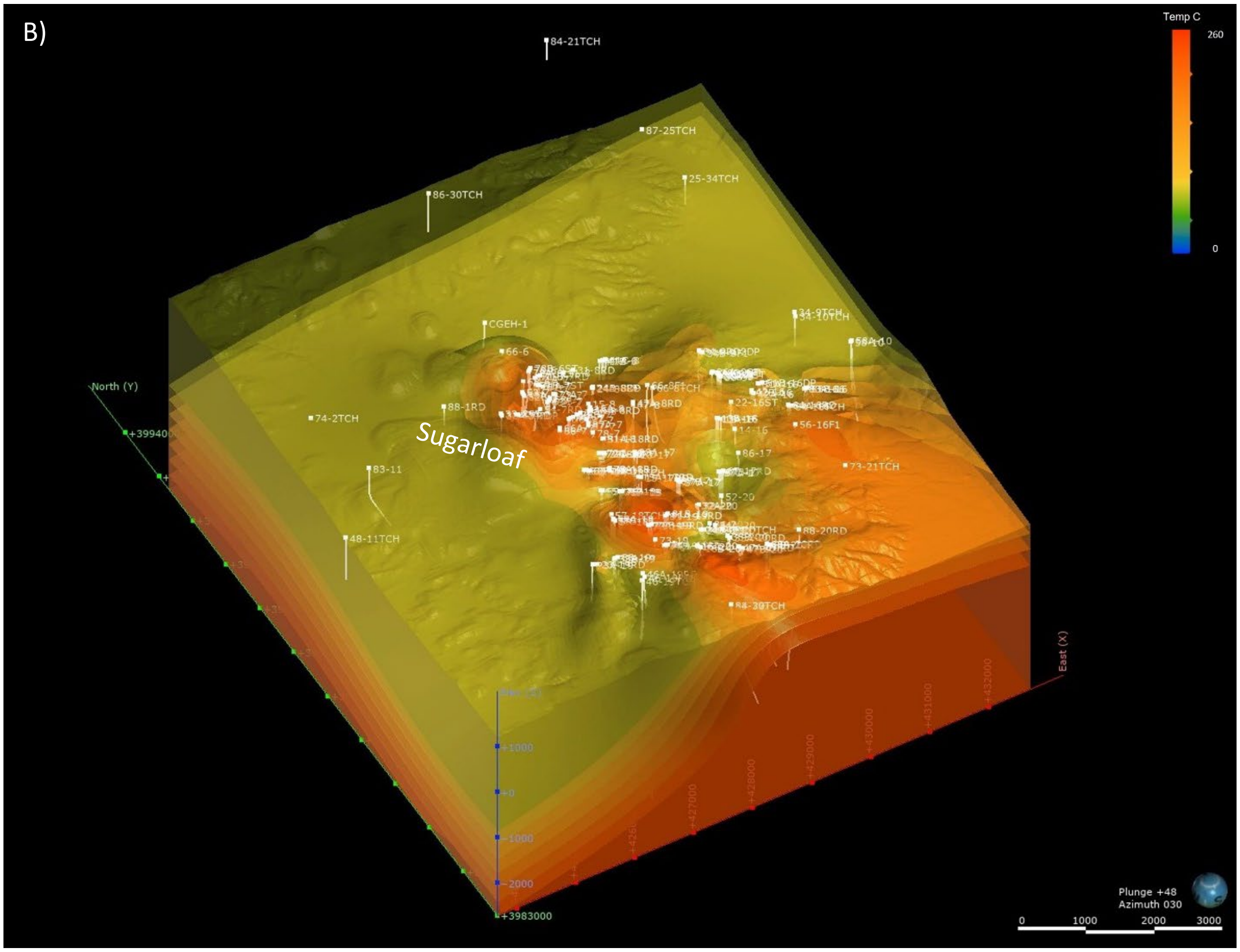


Figure 7: A) An oblique Leapfrog model of downhole temperatures in degrees Celsius using only data collected before the geothermal power plants came online. The data show a prominent heat anomaly in the area near Navy I, east of Sugarloaf, which is similar in location and extent to the anomaly seen in the 2mtp data collected by LeSchack and Lewis around the same time. B) An oblique Leapfrog model of downhole temperatures in degrees Celsius using only data collected after the geothermal power plants came online. This dataset includes downhole temperatures from the area known as the East Flank, which were collected after the geothermal plants came online. The data show heat anomalies in the Main Flank (east of Sugarloaf) as well as the East Flank, which are similar in location and extent to the anomalies seen in the 2mtp data collected by GPO in 2019-2020.

The pre-start-up downhole temperatures were only collected in the Main Flank of the CGF (area around the existing power plants, east of Sugarloaf), whereas the post-start-up temperatures include data from the East Flank. This is why the two models have different extents. Still, the comparison between 2mtp data and the downhole temperatures show that the location of heat anomalies are similar. Both the downhole pre-start-up temperature model and the 2mtp LeSchack and Lewis data show a heat anomaly in the area around Navy I, east of Sugarloaf (Figs. 7A and 6B, respectively). The GPO 2mtp heat anomalies (Fig. 6A) compared to the heat anomalies seen in the downhole temperature model in Figure 7B show that these anomalies are also similar in location. However, the extent of the heat anomaly located in the southern part of the Main Flank is much more pronounced and extensive in the downhole temperature model, than it is in the GPO 2mtp data.

6. Comparing GPO to LeSchack and Lewis 2mtp Data

Once the normalization factors were applied to each phase of 2mtp data collection, a relative comparison could reasonably be made between the GPO dataset and the LeSchack and Lewis dataset. First, the difference between the two datasets were calculated using only GPO 2mtp points that were < 200 m away from LeSchack and Lewis 2mtp points, a total of 41 points. From this process, the GPO 2mtp data were calculated to be 0.68ºC hotter on average than the LeSchack and Lewis 2mtp data. The difference between the GPO and LeSchack and Lewis 2mtp data was first calculated using the raster math tool in ArcGIS® (Fig. 8). The result does not appear to be much different from the Figure 6A map of the GPO 2mtp data. However, Figure 8 does show some temperature changes between the LeSchack and Lewis data and GPO data. For example, temperatures around Navy I and southern East Flank have decreased over time with slight increases in temperature in the northwest CGF.

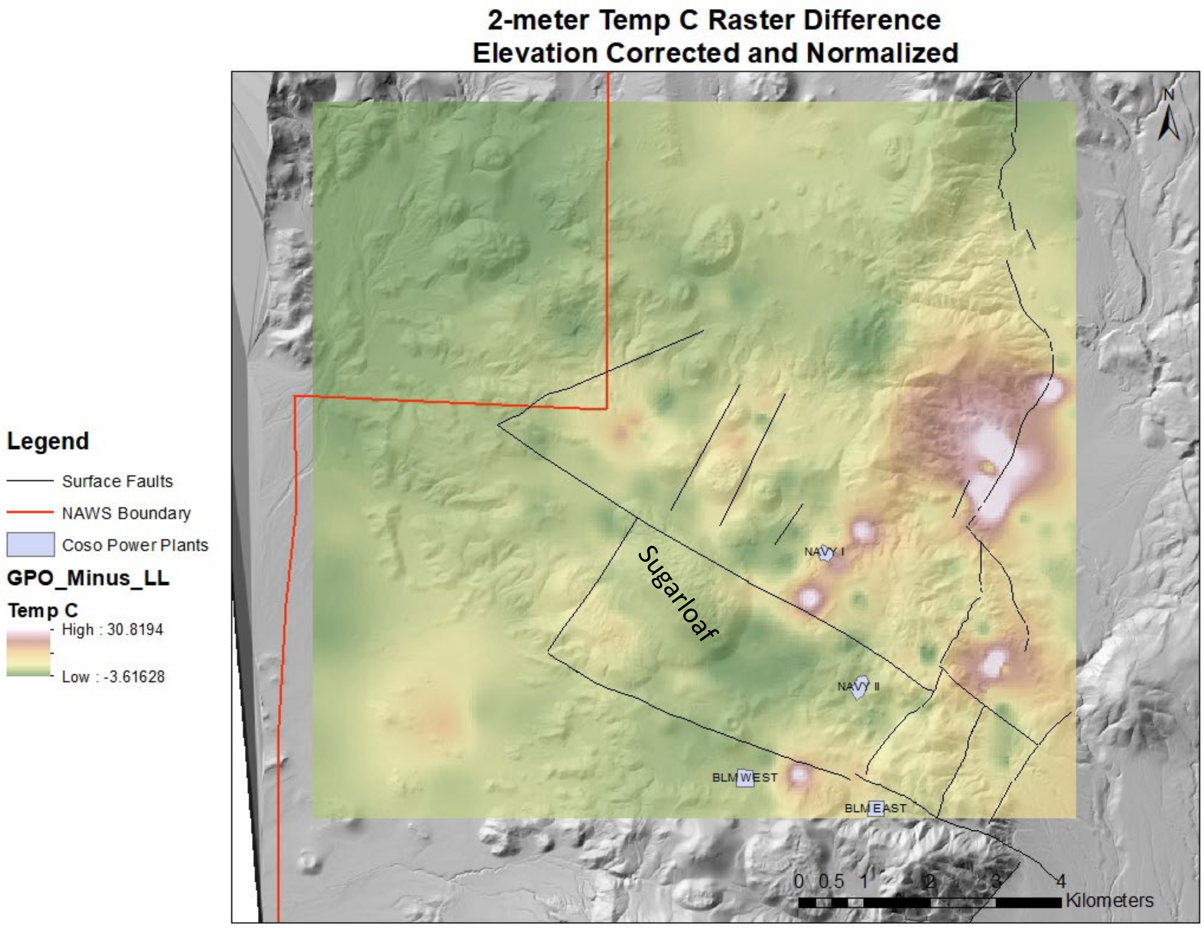


Figure 8: An ArcGIS map of the difference between the GPO 2mtp normalized raster and the LeSchack and Lewis 2mtp normalized raster in degrees Celsius calculated using the raster math tool in ArcGIS®.

In order to better highlight the changes between the LeSchack and Lewis 2mtp data and the GPO 2mtp data, the differences calculated as described above were assigned to the corresponding GPO 2mtp points and an inverse distance weighted interpolation raster was generated from those difference values (Fig. 9).

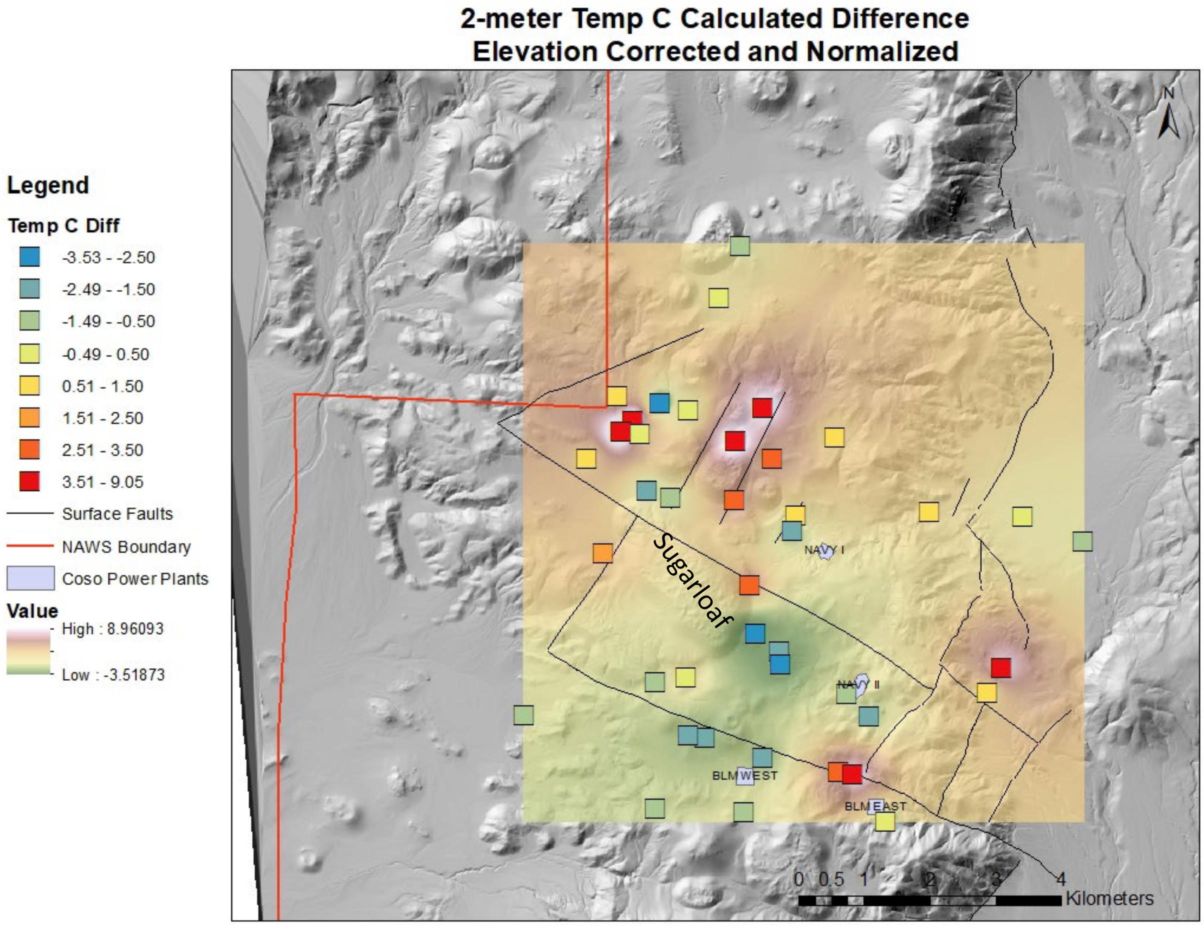


Figure 9: An ArcGIS map of the difference in degrees Celsius between the GPO 2mtp normalized raster and the LeSchack and Lewis 2mtp normalized raster in degrees Celsius using the difference values that were calculated using the 41 GPO 2mtp points that were < 200 m away from LeSchack and Lewis 2mtp points. See text for discussion.

The map in Figure 9 better illustrates the changes in temperature that have occurred since the LeSchack and Lewis 2mtp survey. It is much easier to see that the Main Flank area between Navy I and BLM West has generally gotten cooler and that the northwest area of the CGF seems to have experienced a temperature increase. In addition, the northern East Flank and the area northwest of BLM East have also experienced temperature increases of nearly 9ºC since the LeSchack and Lewis 2mtp survey. We suggest that the increase in the East Flank shallow temperature is due to increased activity in surface manifestations in that area, which is likely the result of changes in permeability at depth over the length of production in this area. There are no obvious surface manifestations in the area northwest of BLM East, but a possible explanation for the temperature increase is that it is due to changes in fluid flow through the subsurface in this portion of the reservoir.

The raster math approach seems to suffer from the fact that the GPO 2mtp survey and the LeSchack and Lewis 2mtp survey do not overlap, the GPO survey has more points to the east and the LeSchack and Lewis 2mtp survey has more points to the west, causing the resulting interpolations of each of the datasets to be quite different. Interpolation errors then become compounded using the raster math approach because another interpolation must be made from the two input interpolations. In contrast, the manual difference calculation approach only goes through one round of interpolation to generate the raster, and the results are constrained to the area of where the 41 calculated points are located, rather than interpolated beyond points where the two surveys do not overlap (Fig. 9). Since the goal was to make a relative comparison between the GPO and LeSchack and Lewis 2mtp surveys, this approach includes enough values to be a reasonable estimate, and visualization, of temperature changes.

7. Conclusions

Even though the current functions describing seasonal 2-meter temperatures are reasonable, seasonal 2mtp data collection should continue at the CGF in order to improve those temperature models. Moving forward, Python tools can be used to make better models of the data.

The approach of normalizing background temperatures to a standard temperature allows for a relative comparison between 2mtp surveys collected at different times and during different seasons without making seasonal corrections. The relative comparison between the recent GPO 2mtp survey and the LeSchack and Lewis 2mtp survey in 1977 shows that 2-meter temperatures may be decreasing in the Main Flank, but increasing in the northern East Flank, the area around BLM East and in the northwestern part of the CGF. The northwestern area requires additional study to confirm these results and determine if the area is suited for further exploration.

Acknowledgements

The GPO would like to thank Dr. Chris Sladek for supplying us with additional 2-meter temperature probes to complete our 2mtp survey. Dr. Mark Coolbaugh for sharing his insight and experience with 2mtp surveys. Finally, we thank Dr. Ole Kaven for taking the time to apply preliminary Python tools to the seasonal 2mtp data.

REFERENCES

Coolbaugh, M.F., Sladek, C., Faulds, J.E., Zehner, R.E., and Oppliger, G.L., “Use of Rapid Temperature Measurements at a 2-Meter Depth to Augment Depper Temperature Gradient Drilling.” *Proceedings, 32nd Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, CA*, Jan. 22-24, (2007), 109-116.

Coolbaugh, M.F., Sladek, C., Zehner, R.E., and Kratt, C., “Shallow Temperature Surveys for Geothermal Exploration in the Great Basin, USA, and Estimation of Shallow Aquifer Heat Loss.” *GRC Transactions*, 38, (2014), 115-122.

Kintzinger, P.R., “Geothermal Survey of Hot Ground Near Lordsburg, New Mexico.” *Science*, 124, (1956), 629-630.

LeSchack, L.A., and Lewis, J.E., "Geothermal Prospecting with Shallow-Temp Surveys." *Geophsyics*, 48, 7, (1983), 975-996.

Noble, L.W., and Ojiambo, S.B., “Geothermal Exploration in Kenya.” *Proceedings 2nd U.N. Symposium on Use of Geothermal Resources, San Francisco*, May 20-29, (1975), 189-204.

Olmsted, F.H., "Use of Temperature Surveys at a Depth of 1 Meter in Geothermal Exploration in Nevada." *United States Geological Survey Professional Paper*, 1044-B, (1977), 25.

Sladek, C., Coolbaugh, M.F., and Zehner, R.E., "Development of 2-Meter Soil Temperature Probes and Results of Temperature Survey Conducted at Desert Peak, Nevada, USA." *GRC Transactions*, 31, (2007), 535-541.

Sladek, C., Coolbaugh, M.F., Penfield, R., Skord, J., and Williamson, L., "The Influences of Thermal Diffusivity and Weather on Shallow Temperature Measurements." *GRC Transactions*, 36, (2012), 793-797.

Sladek, C., and Coolbaugh, M.F., "Development of Online Map of 2 Meter Temperatures and Methods for Normalizing 2 Meter Temperature Data for Comparison and Initial Analysis." *GRC Transactions*, 37, (2013), 333-336.

Trexler, D.T., Koenig, B.A., Ghusn, G., Jr., Flynn, T., and Bell, E.J., "Low-to-Moderate-Temperature Geothermal Resource Assessment for Nevada: Area Specific Studies, Pumpernickel Valley, Carlin and Moana." *United States Department of Energy Geothermal Energy Report*, NV/10220-1, DE82018598, (1982).

APPENDIX 1

GPO 2mtp survey data for all phases including elevation corrected temperatures and normalized temperatures in degrees Celsius.

Label	Phase	2mt_C	ElevCorr_C	Norm_C	x	y	z
55	2	26	28.489	25.779	422890	3990381	1285.2
51	2	21.83333	26.05833	23.34833	423632	3994883	1458.8
3	2	27.05556	27.55956	24.84956	423534	3985885	1086.7
6	2	26.94444	27.50444	24.79444	422354	3984790	1092.3
7	2	26.5	26.448	23.738	420135	3985449	1031.1
8	2	24	26.25	23.54	426408	3986605	1261.3
10	2	29.16667	31.27467	28.56467	427413	3986864	1247.1
11	2	27	29.116	26.406	427133	3986505	1247.9
12	2	25.66667	27.91667	25.20667	426408	3986605	1261.3
14	2	25.83333	28.00833	25.29833	426884	3984994	1253.8
16	2	29.05556	31.34256	28.63256	427682	3985510	1265
17	2	43	45.2	42.49	427682	3985012	1256.3
19	2	31.16667	33.05767	30.34767	428312	3985031	1225.4
20	2	26.16667	28.44967	25.73967	426271	3985552	1264.6
23	2	24.94444	28.01744	25.30744	426915	3983564	1343.6
25	2	28.66667	30.28067	27.57067	428466	3986081	1197.7
27	2	26.72222	28.35922	25.64922	429615	3986834	1200
28	2	34.33333	35.02833	32.31833	430580	3986238	1105.8
29	2	29.66667	31.26267	28.55267	430045	3988110	1195.9
30	2	46.38889	49.36189	46.65189	427849	3987670	1333.6

31	2	26.94444	29.70344	26.99344	427481	3989505	1312.2
32	2	24.77778	27.69878	24.98878	427131	3990432	1328.4
33	2	26.88889	29.88289	27.17289	426020	3990515	1335.7
34	2	26.44444	30.00944	27.29944	425784	3991372	1392.8
35	2	24.22222	26.27922	23.56922	424826	3988764	1242
36	2	23.66667	28.12067	25.41067	426063	3992602	1481.7
39	2	22.5	27.635	24.925	428665	3991660	1549.8
40	2	25.55556	27.13856	24.42856	432474	3992586	1194.6
41	2	25.83333	28.02533	25.31533	432243	3993687	1255.5
43	2	38.44444	39.05244	36.34244	431048	3990126	1097.1
44	2	26.44444	27.29644	24.58644	433033	3989292	1121.5
45	2	26.94444	27.55644	24.84644	433019	3988197	1097.5
48	2	22.11111	26.20311	23.49311	423591	3993635	1445.5
52	2	23.61111	27.37611	24.66611	424301	3991776	1412.8
54	2	26	27.62	24.91	421216	3991499	1198.3
57	2	26.05556	28.01656	25.30656	422066	3991072	1232.4
58	2	24.88889	27.47789	24.76789	421236	3993662	1295.2
59	2	23.88889	26.96789	24.25789	421738	3994435	1344.2
60	2	23.27778	27.76478	25.05478	426771	3992280	1485
61	2	25.77778	25.87678	23.16678	420661	3983597	1046.2
62	2	25.94444	26.01444	23.30444	420429	3987145	1043.3
67	2	26.77778	27.73378	25.02378	423458	3987466	1131.9
68	2	30.16667	33.27467	30.56467	424939	3987178	1347.1
69	2	26.77778	30.27878	27.56878	424185	3987840	1386.4
72	2	28.11111	31.00711	28.29711	424429	3987602	1325.9
74	2	25.38889	28.54889	25.83889	425015	3987579	1352.3
77	2	28.38889	30.78589	28.07589	426897	3988457	1276
78	2	28.22222	30.53422	27.82422	427325	3988644	1267.5
79	2	32.44444	34.48344	31.77344	428207	3988700	1240.2
80	2	43.05556	45.62556	42.91556	428270	3988219	1293.3
81	2	49.61111	51.35811	48.64811	428629	3988712	1211
82	2	25.05556	27.30156	24.59156	425402	3989305	1260.9
83	2	29	31.883	29.173	428607	3987658	1324.6
84	2	25.27778	25.75678	23.04678	432034	3988538	1084.2
85	2	27	29.012	26.302	428489	3986934	1237.5
86	2	27.27778	27.95578	25.24578	432652	3988996	1104.1
87	2	27.05556	29.30656	26.59656	424727	3989531	1261.4
90	2	22.05556	25.74556	23.03556	422685	3995209	1405.3
91	2	59.27778	59.96778	57.25778	430718	3989839	1105.3
92	2	46.05556	46.86656	44.15656	430350	3989306	1117.4
93	2	33.77778	34.47378	31.76378	430580	3989660	1105.9
95	2	46.88889	47.64689	44.93689	431527	3990864	1112.1
96	2	29.22222	29.93422	27.22422	431861	3990482	1107.5

97	2	27.27778	27.95478	25.24478	432158	3990125	1104
101	2	52.05556	52.77756	50.06756	430602	3989155	1108.5
102	2	46.72222	47.43022	44.72022	430481	3989469	1107.1
103	2	27.38889	27.97389	25.26389	431114	3988902	1094.8
104	2	64.66667	65.40067	62.69067	430683	3986647	1109.7
107	2	29.55556	30.52756	27.81756	430496	3987222	1133.5
108	2	41.27778	42.19978	39.48978	430414	3986808	1128.5
109	2	30.33333	31.59533	28.88533	430118	3987595	1162.5
111	2	33.38889	33.70589	30.99589	430850	3985206	1068
112	2	33.61111	34.50811	31.79811	430185	3985895	1126
113	2	31.72222	32.22622	29.51622	430774	3985985	1086.7
6	3	19.94444	21.39544	26.34544	431621	3992202	1181.4
7	3	16.83333	22.21133	27.16133	426824	3993022	1574.1
8	3	18.22222	22.61422	27.56422	426498	3992229	1475.5
10	3	17.27778	20.88778	25.83778	425871	3991427	1397.3
13	3	19.94444	22.89944	27.84944	424945	3990742	1331.8
15	3	18.16667	21.05567	26.00567	425596	3990625	1325.2
16	3	18.77778	21.53978	26.48978	423548	3990022	1312.5
17	3	27.38889	30.02789	34.97789	425183	3990371	1300.2
18	3	24.22222	27.19122	32.14122	427168	3990557	1333.2
19	3	20.05556	22.58856	27.53856	425300	3990170	1289.6
20	3	27.16667	29.74267	34.69267	425009	3990197	1293.9
22	3	22.16667	25.04567	29.99567	428247	3990107	1324.2
23	3	22.55556	25.44456	30.39456	427311	3989779	1325.2
24	3	26.77778	29.62578	34.57578	426739	3990059	1321.1
25	3	24.05556	26.57556	31.52556	426722	3989160	1288.3
27	3	26.55556	27.67456	32.62456	429688	3988982	1148.2
29	3	23.33333	25.58233	30.53233	427668	3988925	1261.2
30	3	19.88889	22.07389	27.02389	427605	3988690	1254.8
31	3	18.38889	20.56089	25.51089	425759	3989188	1253.5
44	3	18.88889	20.94389	25.89389	424741	3988354	1241.8
46	3	29.16667	31.76867	36.71867	426963	3987872	1296.5
47	3	20.33333	22.46133	27.41133	427052	3987135	1249.1
48	3	20.5	22.543	27.493	427427	3986665	1240.6
50	3	21.11111	23.42711	28.37711	425992	3986468	1267.9
51	3	18.77778	20.80278	25.75278	425522	3986398	1238.8
54	3	19.5	19.937	24.887	422909	3985963	1080
56	3	19.88889	21.55489	26.50489	428443	3986208	1202.9
57	3	18.88889	20.35489	25.30489	428773	3985878	1182.9
59	3	19.05556	21.22956	26.17956	426036	3985579	1253.7
60	3	17.38889	19.58489	24.53489	427167	3985249	1255.9
61	3	26.44444	28.30944	33.25944	428519	3984995	1222.8
62	3	17.94444	20.25744	25.20744	426875	3984417	1267.6

63	3	19.44444	21.46044	26.41044	429021	3984265	1237.9
65	3	25.77778	26.18078	31.13078	422286	3985786	1076.6
66	3	17.72222	20.85222	25.80222	425522	3984462	1349.3
71	3	21.44444	21.89844	26.84844	431809	3987383	1081.7
74	3	20.05556	20.58256	25.53256	431459	3988697	1089
87	3	27.27778	29.91678	34.86678	428858	3987778	1300.2
88	3	27.11111	28.70211	33.65211	429378	3986798	1195.4
89	3	38.22222	38.98122	43.93122	430504	3986309	1112.2
20	1	21.16667	23.30167	27.95167	429249	3984325	1249.8
22	1	17.11111	19.77411	24.42411	424900	3988059	1302.6
21	1	20	22.562	27.212	426385	3986167	1292.5
0	1	20.72222	22.13422	26.78422	431453	3992160	1177.5
1	1	20.55556	21.49756	26.14756	431676	3991271	1130.5
2	1	19.94444	20.49644	25.14644	431736	3988121	1091.5
5	1	27.05556	27.96856	32.61856	430150	3989166	1127.6
6	1	18.5	20.818	25.468	427115	3984584	1268.1
7	1	21	22.378	27.028	423797	3987542	1174.1
9	1	20.05556	22.45156	27.10156	427364	3985919	1275.9
10	1	18.94444	19.33244	23.98244	432207	3987310	1075.1
11	1	28.94444	29.62244	34.27244	430797	3986605	1104.1
12	1	20.83333	23.17533	27.82533	427494	3988250	1270.5
13	1	31.66667	31.93367	36.58367	430936	3985207	1063
14	1	20.05556	22.05156	26.70156	427789	3986676	1235.9
15	1	19.16667	21.52567	26.17567	424492	3989786	1272.2
16	1	18.94444	21.75144	26.40144	431190	3994490	1317
17	1	18	22.493	27.143	428098	3992603	1485.6
18	1	20.55556	21.88456	26.53456	429544	3986059	1169.2