GRSLE Archaeology Iowa State University Anthropology

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Quantifying Ice Patch Variability Using GIS Functionality Introduction

Recently, data recorded by the GRSLE project provide attributes regarding the sizes and areas of ice patches in the Cougar Pass region of north western Wyoming. By relating the change in ice patch areas to conditions, such as rainfall, temperature, and snow water equivalents, a regression equation can be derived that calculates the change ice patch areas relative to key environmental variables. Using this regression equation, a dynamic model may be constructed in GIS to quantify the alteration in ice patch size and area with the change in the respected variables. The model provides insight into how ice patches may have



responded to past climatic variation and help to develop more refined hypotheses about the role that ice patch locations played in prehistoric cultural systems. This model can be expanded to evaluate ice patches existing across the Absaroka mountain region, and to identify locations where they once persisted. Predicting the locations of past ice patches would be a powerful tool for locating archaeological sites among the Absaroka mountain range, and could potentially expand into other mountain archaeological research.

Procuring Data

The Natural Resources Conservation Service (NRCS) provides an open access database retaining SNOTEL records dating back to 1980. Temperatures, precipitation, and snow water equivalents data are all recorded daily at weather stations and stored into downloadable csv. files. Relative to Cougar Pass, there are three weather stations within feasible proximity, Yount's Peak [19.8] km], Kirwin [27.5 km], and Borough Creek [20.1 km]. Though Yount's Peak is the nearest station there is a significant gap in the

data where no records of temperature, precipitation, or snow water equivalence were able to be recorded from October 1st 2013 to August 12th 2015 due to forest fires. In concurrence, Borough Creek, the next nearest weather station, is missing data from October 1st 2013 to July 9th 2014. Therefore, the Kirwin weather station is the nearest complete dataset. Comparing the data between Kirwin an Yount's Peak show the variation to be minimal, temperature has the greatest variation 0.7763, while precipitation and snow water equivalence have the lease 0.9240 and 1.1955 respectively.



Data Sources

"EarthExplorer," United States Geological Survey: Reston, Virginia. Web. < http://earthexplorer.usgs.gov/> "Snow Telemetry (SNOTEL) and Snow Course Data and Products," Natural Resource Conservation Service, *United States Department of Agriculture:* Washington D.C. Web < http://www.wcc.nrcs.usda.gov/snow/>

Thanks to the 2016 GRSLE field team for recording ice patch area data. Special thanks to GRSLE archaeology for sharing GIS data and providing project assistance. Funding provided by Wyoming CLG grant to PCHPC and Shoshone National Forest.





Obtaining Ice Patch Areas

Ice Patch area data was procured using a variety of different methods. Areas from 2015 and 2016 were recorded by GRSLE researchers who encircled individual ice patches while recording GNSS positions, thereby producing high resolution polygons with 40cm accuracy, in addition to areas from 2011 which where digitized on a high resolution image by Larry Todd. Other data are available from the USGS open access satellite imagery database. Using the ArcMap digitizing functionalities, areas from 2014 and 2013 were constructed using Landsat 8 data LC8037030201468LGN00 and LC8037030213217LGN00 taken in September 26, 2014 and August 26, 2013. The accuracy of these digitization's is limited by the Landsat images' 30m resolution. Satellite imagery of the Cougar Pass region from 2012 are not available in feasible resolution from the USGS databases.

Parameter Estimate	s					GL-1
Term	Estimate	Std Error	L-R ChiSquare	Prob>ChiSa	Lower CL	Upper CL
Intercept	14293.213	1.6769e-8	214.22493	<.0001*		· .
AVG_TEMP_C	5635.4193	4.5384e-9	217.23493	<.0001*		
AVG_SNOW_WATER_CM AVG_PRECIP_CM	-1095.051	1.528e-9 1.127e-9	214.9/5/ 215.27324	<.0001*		1
✓ Correlation of Estin	nates					
Corr						
	Intercept AV	G_TEMP_C A	VG_SNOW_	WATER_CM AV	3_PRECIP_CM	
AVG TEMP C	0.9275	1.0000		0.9645	-0.986	
AVG_SNOW_WATER_CM	0.9645	0.9880		1.0000	-0.995	
AVG_PRECIP_CM	-0.986	-0.974		-0.995	1.0000	
A Parameter Estimate	5		L.P.			GL-2
Term	Estimate	Std Error	ChiSquare	Prob>ChiSq	Lower CL	Upper CL
Intercept	-8088.548	9.3796 e -9	7.437e+23	<.0001*		
AVG_TEMP_C	9441.2685	2.5385e-9	1.383e+25	<.0001*		1.1
AVG_SNOW_WATER_CM	-661.7368	6.303e-10	3.950e+24 1.102e+24	<.0001*		
⊿ Correlation of Estim	ates					
Corr						
Internet	Intercept AV	G_TEMP_C A	VG_SNOW_\	NATER_CM AVO	3_PRECIP_CM	
AVG TEMP C	0.9275	1.0000		0.9645	-0.986	
AVG_SNOW_WATER_CM	0.9645	0.9880		1.0000	-0.995	
AVG_PRECIP_CM	-0.986	-0.974		-0.995	1.0000	
⊿ Parameter Estimate	s				GL-	3 & GL-4
			L-R			
Term	Estimate	Std Error	ChiSquare	Prob>ChiSq	Lower CL	Upper CL
AVG TEMP C	142173.79	1.0508e-7	210.02030	<.0001*		
AVG_SNOW_WATER_CM	42309.931	3.5378 e -8	216.93444	<.0001*		
AVG PRECIP CM	-24576.45	2.6093e-8	215.02386	<.0001*		
			213102300			
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✓ Correlation of Estin Corr	nates	G TEMP C	AVG SNOW 1	WATER CM AV	g precip cm	
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 ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term 	nates Intercept AV 1.0000 0.9275 0.9645 -0.986 S Estimate 65395.851 86342.774 23463.491 -12703.65 nates Intercept AV 1.0000 0.9275 0.9645 -0.986 S Estimate Estimate	G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 1.9823e-7 5.3649e-8 1.8062e-8 1.3322e-8 (G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error	L-R ChiSquare 206.63122 219.30985 217.59602 215.12285 AVG_SNOW_Y	WATER_CM AV 0.9645 0.9880 1.0000 -0.995 Prob> ChiSq <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.	G_PRECIP_CM -0.986 -0.974 -0.995 1.0000 GL-5 throug Lower CL	h GL-10A Upper CL
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 ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM ✓ Parameter Estimate 	nates Intercept AV 1.0000 0.9275 0.9645 -0.986 S Estimate 65395.851 86342.774 23463.491 -12703.65 nates Intercept AV 1.0000 0.9275 0.9645 -0.986 S Estimate 7032.702 12560.618 3250.2223	G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 1.9823e-7 5.3649e-8 1.8062e-8 1.3322e-8 'G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 2.7519e-8 7.4477e-9 2.5074e-9	L-R ChiSquare 206.63122 219.30985 217.59602 215.12285 AVG_SNOW_V AVG_SNOW_V L-R ChiSquare 204.5886 219.68427 217.57872	WATER_CM AV 0.9645 0.9880 1.0000 -0.995 Prob>ChiSq <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001*	G_PRECIP_CM -0.986 -0.974 -0.995 1.0000 GL-5 throug Lower CL	h GL-10A Upper CL
 ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM 	nates Intercept AV 1.0000 0.9275 0.9645 -0.986 Estimate 65395.851 86342.774 23463.491 -12703.65 nates Intercept AV 1.0000 0.9275 0.9645 -0.986 Estimate 7032.702 12560.618 3250.2223 -1719.298	G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 1.9823e-7 5.3649e-8 1.8062e-8 1.3322e-8 1.3322e-8 (G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 2.7519e-8 7.4477e-9 2.5074e-9 1.8494e-9	L-R ChiSquare 206.63122 219.30985 217.59602 215.12285 AVG_SNOW_Y AVG_SNOW_Y L-R ChiSquare 204.5886 219.68427 217.57872 214.91955	WATER_CM AV 0.9645 0.9880 1.0000 -0.995 Prob> ChiSq <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.000*	G_PRECIP_CM -0.986 -0.974 -0.995 1.0000 GL-5 throug Lower CL	h GL-10A Upper CL
 ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim 	nates Intercept AV 1.0000 0.9275 0.9645 -0.986 Estimate 65395.851 86342.774 23463.491 -12703.65 nates Intercept AV 1.0000 0.9275 0.9645 -0.986 Estimate 7032.702 12560.618 3250.2223 -1719.298 mates	G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 1.9823e-7 5.3649e-8 1.8062e-8 1.3322e-8 / / G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 2.7519e-8 7.4477e-9 2.5074e-9 1.8494e-9	L-R ChiSquare 206.63122 219.30985 217.59602 215.12285 AVG_SNOW_V L-R ChiSquare 204.5886 219.68427 217.57872 214.91955	WATER_CM AV 0.9645 0.9880 1.0000 -0.995 Prob> ChiSq <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001*	G_PRECIP_CM -0.986 -0.974 -0.995 1.0000 GL-5 throug Lower CL	h GL-10A Upper CL
 ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim AVG_PRECIP_CM ✓ Correlation of Estim AVG_PRECIP_CM 	nates Intercept AV 1.0000 0.9275 0.9645 -0.986 S Estimate 65395.851 86342.774 23463.491 -12703.65 nates Intercept AV 1.0000 0.9275 0.9645 -0.986 S Estimate 7032.702 12560.618 3250.2223 -1719.298 mates	G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 1.9823e-7 5.3649e-8 1.8062e-8 1.3322e-8 (G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 2.7519e-8 7.4477e-9 2.5074e-9 1.8494e-9	L-R ChiSquare 206.63122 219.30985 217.59602 215.12285 AVG_SNOW_Y L-R ChiSquare 204.5886 219.68427 217.57872 214.91955	WATER_CM AV 0.9645 0.9880 1.0000 -0.995 Prob> ChiSq <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.000*	G_PRECIP_CM -0.986 -0.974 -0.995 1.0000 GL-5 throug Lower CL	h GL-10A Upper CL GL-11 Upper CL
 ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr ✓ Correlation of Estim 	nates Intercept AV 1.0000 0.9275 0.9645 -0.986 es Estimate 65395.851 86342.774 23463.491 -12703.65 nates Intercept AV 1.0000 0.9275 0.9645 -0.986 tes Estimate 7032.702 12560.618 3250.2223 -1719.298 mates Intercept A' 1.0000	G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 1.9823e-7 5.3649e-8 1.8062e-8 1.3322e-8 / /G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 2.7519e-8 7.4477e-9 2.5074e-9 1.8494e-9 // VG_TEMP_C 0.9275	L-R ChiSquare 206.63122 219.30985 217.59602 215.12285 AVG_SNOW_V L-R ChiSquare 204.5886 219.68427 217.57872 214.91955 AVG_SNOW_	WATER_CM AV 0.9645 0.9880 1.0000 -0.995 Prob> ChiSq <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001*	G_PRECIP_CM -0.986 -0.974 -0.995 1.0000 GL-5 throug Lower CL	h GL-10A Upper CL
 ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estin Corr ✓ Correlation of Estin Corr 	nates Intercept AV 1.0000 0.9275 0.9645 -0.986 S Estimate 65395.851 86342.774 23463.491 -12703.65 nates Intercept AV 1.0000 0.9275 0.9645 -0.986 S Estimate 7032.702 12560.618 3250.2223 -1719.298 mates Intercept AV 1.0000 0.9275	G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 1.9823e-7 5.3649e-8 1.8062e-8 1.3322e-8 (G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 2.7519e-8 7.4477e-9 2.5074e-9 1.8494e-9 VG_TEMP_C 0.9275 1.0000	L-R ChiSquare 206.63122 219.30985 217.59602 215.12285 AVG_SNOW_Y L-R ChiSquare 204.5886 219.68427 217.57872 214.91955 AVG_SNOW_Y	WATER_CM AV 0.9645 0.9880 1.0000 -0.995 Prob> ChiSq <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.000*	G_PRECIP_CM -0.986 -0.974 -0.995 1.0000 GL-5 throug Lower CL	h GL-10A Upper CL
 ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Parameter Estimate Term Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_PRECIP_CM ✓ Correlation of Estim Corr Intercept AVG_TEMP_C AVG_SNOW_WATER_CM AVG_TEMP_C AVG_SNOW_WATER_CM 	nates Intercept AV 1.0000 0.9275 0.9645 -0.986 es Estimate 65395.851 86342.774 23463.491 -12703.65 nates Intercept AV 1.0000 0.9275 0.9645 -0.986 es Estimate 7032.702 12560.618 3250.2223 -1719.298 mates Intercept AV 1.0000 0.9275 0.9645 -0.986 es	G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 1.9823e-7 5.3649e-8 1.8062e-8 1.3322e-8 1.3322e-8 (G_TEMP_C / 0.9275 1.0000 0.9880 -0.974 Std Error 2.7519e-8 7.4477e-9 2.5074e-9 1.8494e-9 VG_TEMP_C 0.9275 1.0000 0.9880	L-R ChiSquare 206.63122 219.30985 217.59602 215.12285 AVG_SNOW_V L-R ChiSquare 204.5886 219.68427 217.57872 214.91955 AVG_SNOW_	WATER_CM AV 0.9645 0.9880 1.0000 -0.995 Prob> ChiSq <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0001* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.0000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <.000* <	G_PRECIP_CM -0.986 -0.974 -0.995 1.0000 GL-5 throug Lower CL -0.986 -0.974 -0.995 1.0000 Lower CL -0.986 -0.974 -0.995 1.0000	h GL-10A Upper CL





Generalize	ed Linear M	odel Fi	t				
erdispersion p sponse: CHAN tribution: Nor k: Identity	arameter estim GE_ICEPATCH_ mal	ated by N AREA	laximum Lik	elihood			
imation Metho	d: Maximum L	.ikelihood	1				
Whole Mo	oum wgts) = 4 del Test	+					
Whole mo		1	R				
Model -I	ogLikelihood	ChiSqua	are DF	Prob>ChiSq			
Difference Full Reduced	111.886411 -78.512618 33.3737931	223.77	728 3	<.0001*			
Goodness Of	55.575755						
Fit Statistic	ChiSquare	DF Pr	rob>ChiSq	Overdispersi	ion		
Pearson	0.0000	0		0.00	000		
	0.0000	0					
Effect Sum	mary						
Courses		LogWort	b			PV-alue	
AVG_TEMP_	с	48.44	0	· · · · ·		0.00000	
AVG_PRECIP	_CM	48.01	3			0.00000	
AVG_SNOW	_WATER_CM	47.94	.8			0.00000	
<u>Remove</u> Ac	Id Edit Fl	DR					
Effect Test	s						
c .			L-R	1. 6116			
AVG TEMP C		1 217	Quare Pro .23493	<.0001*			
AVG_SNOW_W	VATER_CM	1 21	4.9757	<.0001*			
AVG_PRECIP_C	M	1 215	.27324	<.0001*			
Parameter	Estimates			LD			
		stimate	Std Error	ChiSquare	Prob>ChiSq	Lower CL	Upper CL
Term	l l	000.040	1.6769e-8	214.22493	<.0001*		
Term Intercept	14 14	1293.213					
Term Intercept AVG_TEMP_C	14 56 (ATER CM 14	535.4193	4.5384e-9	217.23493	<.0001*		
Term Intercept AVG_TEMP_C AVG_SNOW_V AVG_PRECIP_C	14 56 VATER_CM 14 M -	1293.213 535.4193 130.4924 1095.051	4.5384e-9 1.528e-9 1.127e-9	217.23493 214.9757 215.27324	<.0001* <.0001* <.0001*		
Term Intercept AVG_TEMP_C AVG_SNOW_V AVG_PRECIP_C Studentize	14 56 VATER_CM 14 :M -	293.213 535.4193 130.4924 1095.051 Residu	4.5384e-9 1.528e-9 1.127e-9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*	:	
Term Intercept AVG_TEMP_C AVG_SNOW_W AVG_PRECIP_C Studentize 700000-	1 14 56 VATER_CM 14 :M - 1 d Deviance	4293.213 535.4193 430.4924 1095.051 Residu	4.5384e-9 1.528e-9 1.127e-9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*	· ·	
Term Intercept AVG_TEMP_C AVG_SNOW_W AVG_PRECIP_C Studentize 700000-	14 56 VATER_CM 14 :M - ⁻¹ d Deviance	4293.213 535.4193 130.4924 1095.051 Residu	4.5384e-9 1.528e-9 1.127e-9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*	· ·	
Term Intercept AVG_TEMP_C AVG_SNOW_V AVG_PRECIP_C Studentize 700000- 600000-	14 56 VATER_CM 14 :M - d Deviance	4293.213 535.4193 430.4924 1095.051 Residu	4.5384e-9 1.528e-9 1.127e-9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*	· ·	:
Term Intercept AVG_TEMP_C AVG_SNOW_W AVG_PRECIP_C Studentize 700000- 600000- 500000-	14 56 VATER_CM 14 :M d Deviance	293.213 535.4193 430.4924 1095.051 Residu	4.5384e9 1.528e9 1.127e9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*		
Term Intercept AVG_TEMP_C AVG_SNOW_W AVG_PRECIP_C Studentize 700000- 600000- 500000- 900000- 900000- 90000- 90000- 90000- 90000- 90000- 90000- 90000- 90000- 900000- 9000- 9000- 9000- 9000- 9000- 9000- 90000- 90000- 90000- 9000- 9000- 9000- 9000- 9000- 90000- 90000- 9000- 9000- 90000- 90000- 9000- 90000- 90000- 90000- 90000- 90000- 90000- 90000- 90000- 9000- 90000- 90000- 90000- 90000- 9000- 90000- 90000- 9000- 9000- 90000- 90000- 900- 90000- 9000	14 56 VATER_CM 14 :M d Deviance	293.213 535.4193 430.4924 1095.051 Residu	4.5384e-9 1.528e-9 1.127e-9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*	· ·	
Term Intercept AVG_TEMP_C AVG_SNOW_V AVG_PRECIP_C Studentize 700000- 600000- 500000- 9 400000- 300000-	14 56 VATER_CM 14 :M - ⁻¹ d Deviance	4293.213 535.4193 430.4924 1095.051 Residu	4.5384e-9 1.528e-9 1.127e-9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*		
Term Intercept AVG_TEMP_C AVG_SNOW_W AVG_PRECIP_C Studentize 700000- 600000- 10000- 10000- 10000- 10000- 10000- 100000- 100000- 100000- 100000- 100000- 100000- 100000- 100000- 10000- 100000- 100000- 100000- 100000- 100000- 10000- 10000- 100000- 10000- 10000- 10000- 10000- 10000- 10000- 10000- 10000- 10000- 10000- 10000- 10000- 10000- 10000- 1000- 1000- 10000- 10000- 10000- 10000- 10000- 100	I 14 56 VATER_CM 12 - - - - - - - - - - - - -	293.213 535.4193 430.4924 1095.051 Residu	4.5384e9 1.528e9 1.127e9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*		
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Term Intercept AVG_TEMP_C AVG_SNOW_V AVG_PRECIP_C Studentize 700000- 600000- 900000- 900000- 900000- 900000- 100000- 0- 00-	d Deviance	1293.213 535.4193 130.4924 1095.051 Residu	4.5384e9 1.528e9 1.127e9 al by Pre	217.23493 214.9757 215.27324 dicted	<.0001* <.0001* <.0001*		

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ICE PATCH AR	SITES	AUGUST_2011	CHANGE IN AREA 2011-2013	AUGUST_2013	CHANGE IN AREA 2013-2014	AUGUST_2014	CHANGE IN AREA 2014-2015	AUGUST_2015	CHANGE IN AREA 2015-2016	AUGUST_2016
	GL-1	5397.565216	-1370.340043	4027.225174	-2476.729253	1550,495921	-460.5224428	1089.973478	236.3887045	1326.362182
	GL-2	9218.560081	-5399.609732	3818.950349	-2288.465543	1530.484806	1037.04147	2567.526276	-184.3774586	2383.148818
	GL-3			4574.634584		9186.68777		3656.566562		2849.024627
	GL-4	59207.83967	-50459.61599	4173.589095	8166.673327	7728.209236	-9591.023874	3667.306571	-1831.043298	2643.805208
	GL-5			8761.566492		11514.99582		8844.625061		7116.066421
	GL-6			4168.83481		3993.003208		3947.78432		3227.374537
	GL-7					3752.047897		2649.316877		2146.456139
	GL-7A					486.15151		215.666642		242.2919312
	GL-8			2431.301654		1461.789135		1350.306825		1032.8559
	GL-9			590.8520385		342.3427125	1	458.5762785		344.5118304
	GL-10			1090.544268		443.7128216	i	797.5005564		670.3307175
	GL-10A	61188.64495	-37648.24447	1479.898625	-997.4655575	548.8918154	-4106.434032	172.7243233	-3509.529054	147.0843538
	GL-11	8491.221304	-5577.653285	2913.568019	-494.9503657	2418.617653	-214.3646906	2204.252962	-350.8594912	1853.393471
	GL-7B			619.2081738	-167.922004	451.2861698	-112.2786492	339.0075206		
	GL-7C				0			114.0228027		

ArcPlugin

A Plugin tool that takes three inputs, average annual temperature, precipitation, and snow water equivalence, and has the user select the ice patch they wish to manipulate, generates a predicted ice patch layer which abides by the regression equation relative to the users designated variables. This Plugin (version 0.2) was programed in Python and currently serves as a preliminary framework for constructing more powerful tools. Particularly, an ice patch predictability model that takes multiple variables and assess various data for locations with the necessary conditions for ice patches to reside.

area_prediction_bar		- ×
Average Temp 1.4185	- Average Snow Water Equivalent 9.3979	-
Average Rain Fall 32.3902	- Site GL-1 - Calculate	

Refining the Algorithm

Several factors greatly effect the capabilities and accuracy of this model. Unfortunately, the nearest it an inapplicable data source for models incorporating areas from 2013 to 2015. The data from Kirwin variable readings between individual ice patches, which currently do not exist. In addition to better variable readings, higher resolution satellite imagery would allow for more accurate measurements of 2011 which was digitized over a much higher resolution image than 2014 and 2013 (30m resolution).

weather station to Cougar Pass, Yount's Peak, is missing a portion of significant data, thereby rendering are certainly useable in place of Yount's Peak, yet are less ideal. The most ideal data would require exact the change in area. The data from 2015 and 2016 are exceptionally accurate (40 cm accuracy), as well as Conclusion

This ArcPlugin serves as a preliminary framework for more capable ice patch models. Currently, the Plugin is limited to only three variables, average annual temperature, precipitation, and snow water equivalence, and assumes that the said variables are responsible for 100% of an ice patch's change in area. Other variables such as elevation, ice patch thickness, wind direction, slope, ground material, and the ratio of ice to foreign materials, all certainly effect the change in ice patch area relative to time. By incorporating a greater array of variables, the regression equation can provide insight into both, the variation between ice patch sizes, and work towards a model for predicting past of ice patch locations. Implementing this plugin into the 2017 GRSLE Archaeology field season at Cougar Pass could prove to be an effective tool in locating archaeological material left behind by extinct ice patches and determining the accuracy of the predictability algorithm. Copies of this poster available at

74th Plains Anthropological Conference October 13, 2016.

Regression Analysis

JMP statistical analysis software provides a fit by model functionality where a dependent variable y (the change in ice patch area) is calculated on a generalized linear model against three **x** variables (average annual temperature, precipitation, and snow water equivalence). Using environmental data from the Kirwin weather station and ice patch area data from GRSLE and LANDSET digitization provides all the necessary variables to construct this model.

GL-1	CHANGE_ICEPAT	AVG_TEMP_C	AVG_SNOW_WATER_CM	AVG_PRECIP_CM
AVG_2016	236.3887045	1.418569254	9.379906849	32.39021918
AVG_2015	-460.5224428	1.628510379	9.829241758	34.69402747
AVG_2014	-2476.729253	0.099206349	18.35568681	39.80333516
AVG_2013	-1370.340043	0.741758242	9.189357143	30.12551648
AVG_2011		0.467032967	15.88128022	37.95834615
AVG_2010		-0.246575342	10.0945863	29.46191233

Four intervals for the change in annual ice patch area are derived for each individual ice patch, resulting in a total of 20 data sets. In 2011, the ice patch area data showed that multiple ice patches did not melt enough to separate into independent areas, particularly GL-3 and GL-4, and GL-5 through GL-10A. As such, the change in areas of these ice patches are evaluated in whole relative to their corresponding annual change.



www.grsle.org/Conferences/Dalmas_et_al_2016.pdf Or via this QR code)