Climate Drivers of Interior Alaska Wildland Fire (1994-2017)

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1. Introduction

As the temperature of the earth gradually increases due to increased greenhouse gases, Arctic precipitation rates and moisture levels are also increasing which will have consequences for wildland fires in Alaska (Bintanja and Andry, 2017). The record since 1940 for the annual number of acres burned suggests an increase of larger fires since 1980 (Fig. 1). Higher warm season temperatures and earlier snow melts means that soils are able to dry for longer periods before the July rains begin in Alaska, increasing the chances of drought conditions and lengthening the fire season. These longer, dryer periods also increase the chances that forest fires will burn longer and more intensely (Chapin et al., 2008; Union of Concerned Scientists, 2018). Since the mid-1980s, forest fires in Alaska have been increasing in duration and frequency, burning more acreage and lasting longer and this trend is projected to continue throughout this century (Kasischke et al., 2010). In an attribution study, Partain et al. (2016) found the following. “Human-induced climate change may have increased the risk of a fire season of this severity by 34%–60%.”

Fires influences both the atmospheric composition and the land surface configuration where wildfire induced land-cover changes can impact clouds and precipitation formation (Mölders, and Kramm, 2007). Enhanced rainfall rates will considerably lower the surface albedo of snow and sea ice when insolation is relatively high, thereby reinforcing surface warming and snow/ice retreat (Bintanja, and Andry, 2017). The subsequent deposition of black carbon aerosols after a fire episode on glaciers, snowpack, and ice sheets, may also reduce surface albedo causing atmospheric heating that subsequently enhances surface melting (Randerson et al. 2006).

Since the Polar regions are experiencing the most rapid rises in global temperatures, it is these areas which are most likely to experiences the negative impacts of climate change (Serreze and Barry, 2011). Generally, the climate of Alaska has been linked with the large-scale climate variability (e.g., Bieniek et al., 2011). The influence of recent ENSO events, warming of ocean temperatures in the Equatorial Pacific, has contributed to extreme warming (Di Liberto, 2018). The mean annual temperature in Alaska's boreal forests has increased by at least 1.5 °C during the past fifty years and this increase is projected to climb to between 3°C

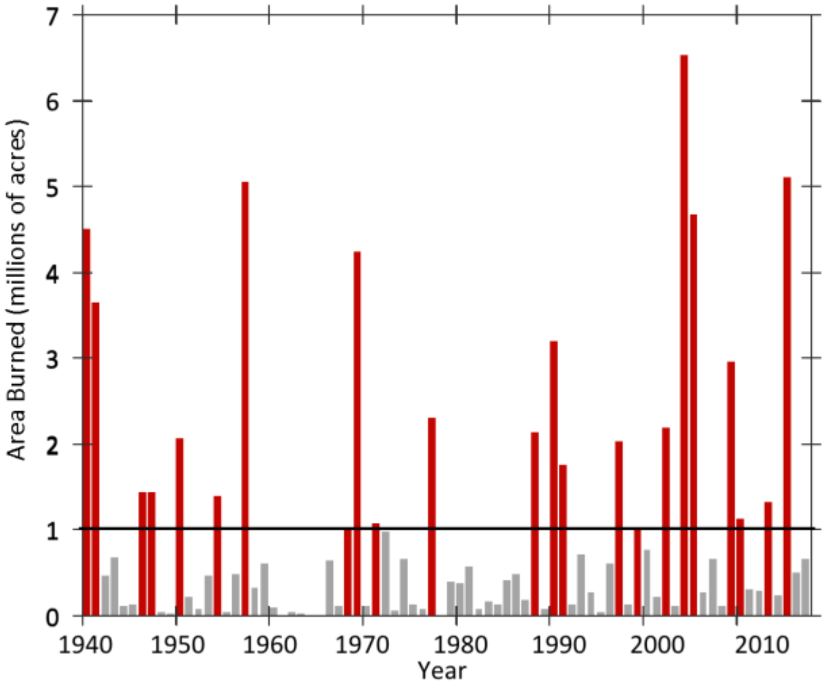


Figure 1. Yearly time series of area burned in Alaska from 1940 -2018. Adapted from Partain et al. (2016). display the large fires (>1M acres) based on area burned in red.

and 7 °C by end of the 21st Century (Verbyla, 2001). Scientists have predicted that globally moist, forested areas are the most likely to face the greatest threats from forest fires as conditions grow hotter and drier (Brändlin, 2018). In Alaska, one recent study of future temperature and precipitation extremes found increased warm days, increased rain extremes, and decreased length of dry periods (Lader et al. 2017). This shows that the future in Alaska is not simple to project and needs a better understanding of processes in the observational record. According to Li et al. (2017), wildfires on a global scale burn approximately 400 million hectares (~400 Mha) of land every year. Under current climatic conditions, Chambers et al. (2005) estimate that around ∼3 Mha of North American boreal forests burns annually. This rate has doubled in recent decades and has been linked to high-latitude warming, (Brändlin, 2018). The extent and intensity of boreal fires are projected to continue or accelerate through the 21st century under the increasingly becoming warmer and drier climate as expected with climate change (Brändlin, 2018).

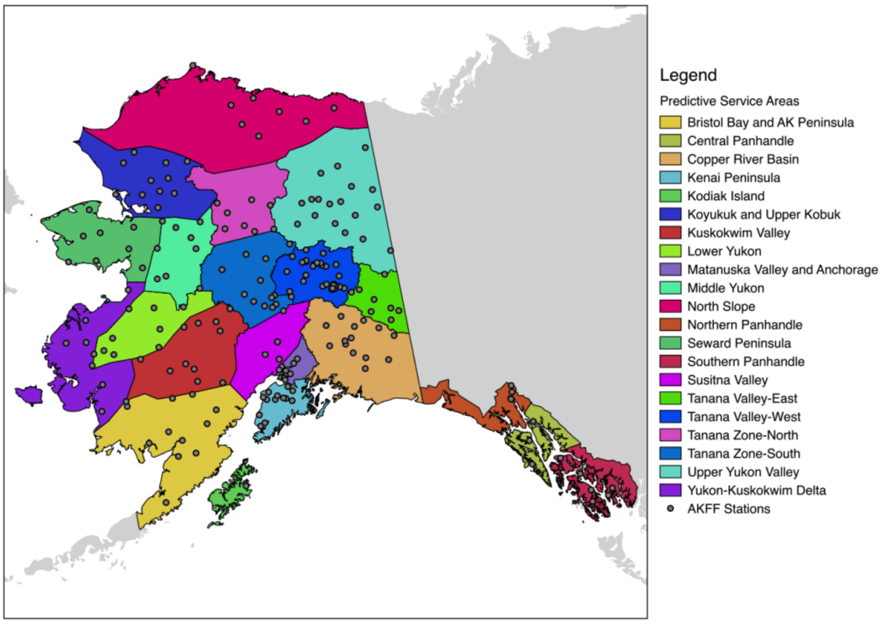


Figure 2. Map showing locations of stations used in this analysis and identification of Predictive Service Areas. Figure provided by P. Bieniek.

The primary objective of this study is to examine the climate drivers of wildfire in interior Alaska where the largest fires occur. We analyse climate data provided by the Bureau of Land Management over management areas defined as Predictive Service Areas (PSAs) over the period 1994 to 2017, where station observations are available (Fig. 2). Relationships between meteorological variables and area burned are investigated to identify the spatial and temporal variability at the PSA level. This study also aims to identify which of the PSAs display similar relationships between climate parameters. Finally, the influence of the temperature and precipitation variability on wildland fire in Alaska was considered in the analysis.

2. DATA AND METHODS

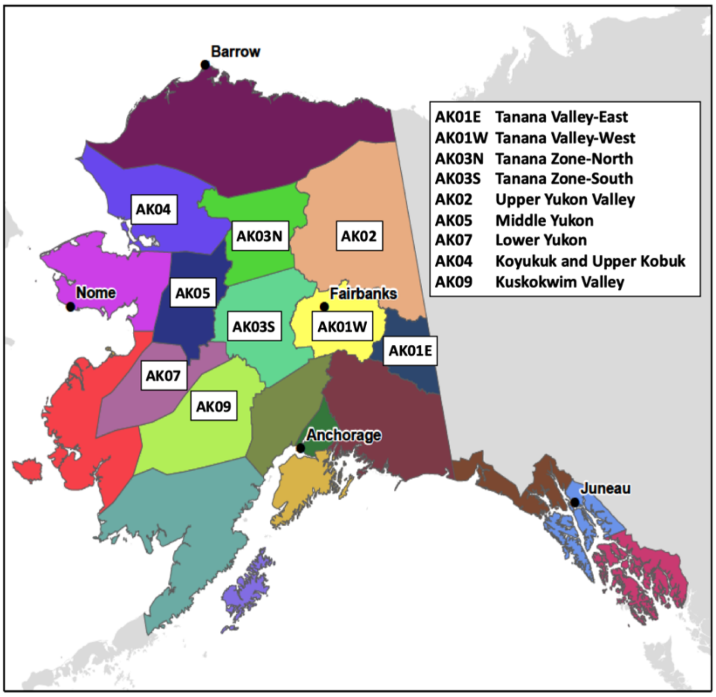


Figure 3. Identification of Predictive Service Areas, PSAs, in the Boreal Interior that are the focus of this study. Include nine PSA distributed as shown in the map.

2.1 Observational data in Predictive Service Areas

Predictive Service Areas (PSAs) were developed for organizing fire management and are based on weather, climate, and landscape features. These divisions were not established using objective methods but reply on local expert knowledge of forecasters. The PSAs cover all of Alaska and are divided into the following groups: South Central Boreal, Costal, Tundra, and Boreal Interior. Nine of the PSA's areas are located in Boreal Interior and will be the focus of our study (Fig. 3 and Table.1).

Table 1 Names and codes for the nine Predictive Service Areas (PSAs) in the interior of Alaska used in this study.

PSA_NAME	CODE
Kuskokwim Valley	AK09
Tanana Valley-West	AK01W
Tanana Zone-South	AK03S
Koyukuk and Upper Kobuk	AK04
Lower Yukon	AK07
Middle Yukon	AK05
Upper Yukon Valley	AK02
Tanana Zone-North	AK03N
Tanana Valley-East	AK01E

For fire management purposes, data are collected and quality controlled at stations beyond the first order National Weather Service stations to collect daily 2-m air temperature, daily precipitation, 10-m winds and humidity. These data are then used by the Alaska Fire Service to calculate the Canadian Fire weather indices (Stocks et al., 1989) to monitor the condition of fuels for evaluating the potential for fire. This study will investigate relationships at the monthly and seasonal time scale focusing on summer temperature and precipitation over the 23 year period from 1994 to 2017.

Data for annual area burned has been kept by the Alaska Fire Service. Since 1940. It is based on a variety of techniques to mark perimeters that include ground based and airborne monitoring. The data are available as annual values of area burned for all of Alaska as well as for each PSA for the period of study (1994 to 2016). Daily acres burned for the entire state are available for the 2004-2017 period and are also explored in this study.

Historical lightning strike locations and times were obtained from the Alaska Interagency Coordination Center. The Alaska lightning observation uses a system of ground-based sensors (Fig.4) that were first tested in late 1970s (Krider et al. 1980) and the archive used in this analysis covered 1986-2017. The system has been upgraded multiple times changing the detection sensitivity therefore the data need to be homogenized for climate-scale analysis. The most major system upgrade occurred in 2012 and began counting individual flashes therefore strike multipliers retained in the historical data 1986-2011 are used here to combine the periods. Daily strikes counts were compiled and homogenized over the 20-km downscaling grid cell for ease of comparison with reanalysis data. Additional improvements in the homogenization approach are still needed and long-term trends cannot be fully trusted. Bieniek et al. (2020) compared this lightning data to climate parameters to identify meteorological proxies for lightning and found variation across PSAs as to which variables (e.g., 2m Temperature, convective precipitation, 500 hPa height) best described lightning strikes.

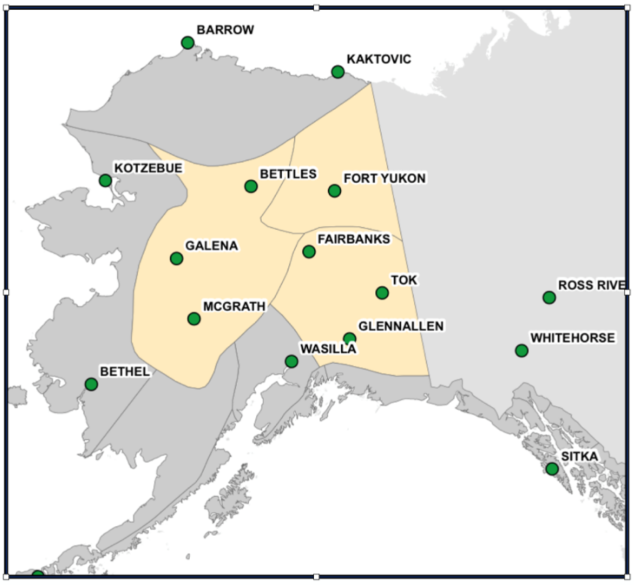


Figure 4. Figure showing the lightning sensor locations by using data from the Alaska Interagency Coordination Center 1986-2017. Figure is from Bieniek et al. (2020).

2.2 Analysis methods

This study applies standard statistical methods that include calculating the mean and standard deviation. Trends are calculated using the least-squares methods for the climate parameters and evaluated for significance. Relationships between variables are calculated using the correlation coefficient and are assessed for statistical significance using a one tailed t-test.

The correlation coefficient identifies the linear co-variability between two series. It is measured on a scale that varies from + 1 to – 1. When one variable increases as the other increases the correlation is positive; when one decreases as the other increases the correlation is negative. Calculation of the correlation between temperature, precipitation and area burned has been done to identify the temporal covariability between series.

3. RESULTS AND DISCUSSION

Changes in temperature and precipitation impact fire weather in complex ways. Warmer temperatures favour10 a higher chance of wildland fires but precipitation plays a double role in influencing the risk of fire. Although precipitation limits the increase in forest fires, the accompanying lightning increases the chance of fires.

Figure 5 displays seasonal mean precipitation in Interior Alaska based on the station data collected from 1994 to 2017. Summer climatological temperatures increase from May to June, reach their peak in July and then begin to cool off in August and September (Fig. 5a). There is an upward trend in temperature especially in May, which means an increase during the snow free period that increases the potential for fire (Fig. 5b). The seasonal cycle of monthly precipitation increases from May to June and peaks in July and August before decreasing in September (Fig. 5c). Monthly averaged precipitation has increased in all months but most substantially in July and September (Fig. 5d).

Overall, Boreal Alaska is warming at the start of summer and becoming wetter during the peak rainfall month of July and also in September. A similar pattern was observed between PSAs for example, the amount of precipitation increased in July on the eastern side while the western side shows increase in August which indicates the role of geographical conditions in creating similarities and differences between areas of study.

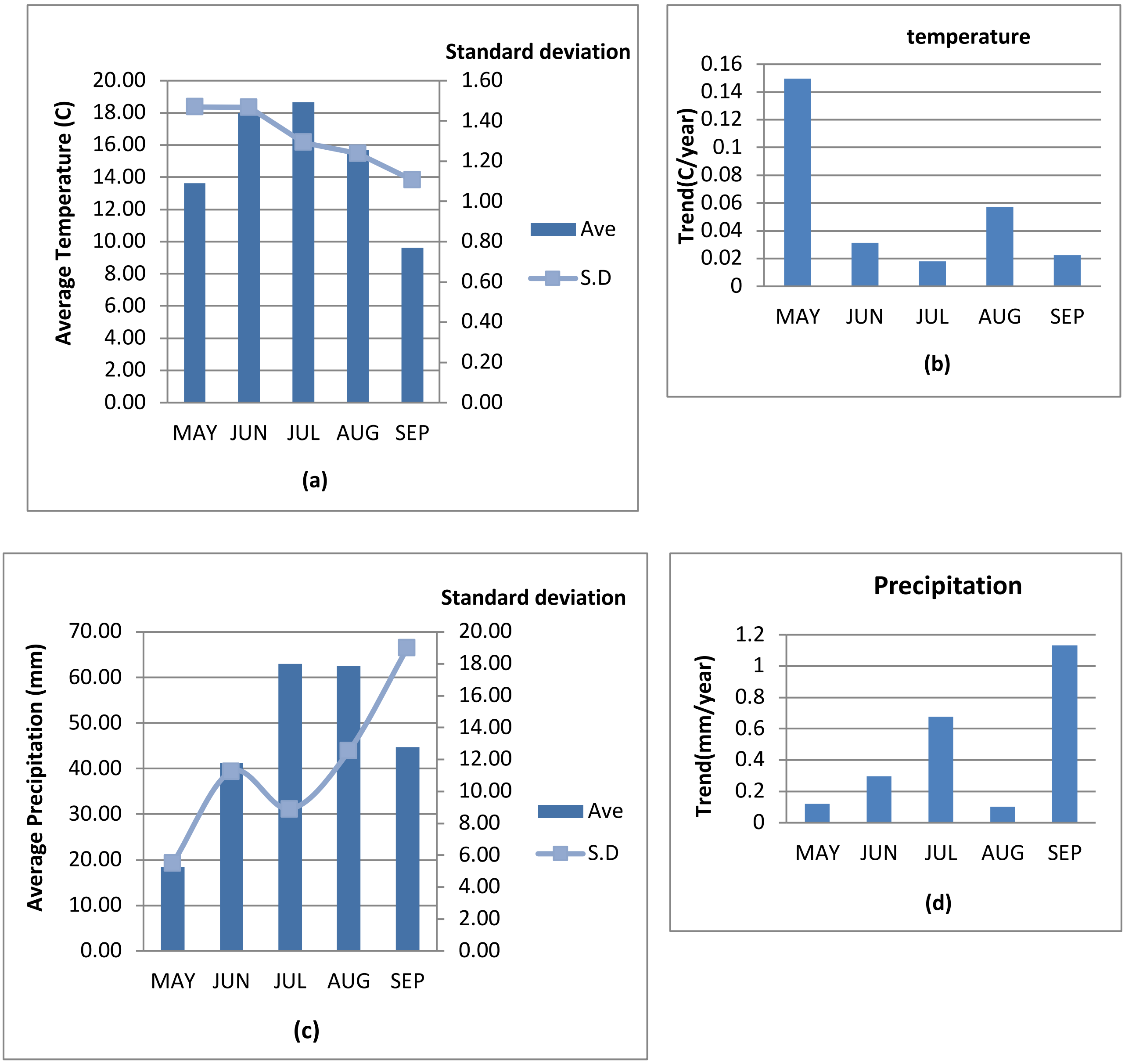


Figure 5. Summer climatological temperature and Precipitation in Interior Alaska based on an average of Boreal PSAs for the period 1994-2017. The panels show: (a) seasonal average temperature and standard deviation, (b) average temperature trends, (c) monthly average total precipitation (mm) and standard deviation, and (d) average precipitation trends (mm year^{-1}) at the PSAs level**.**

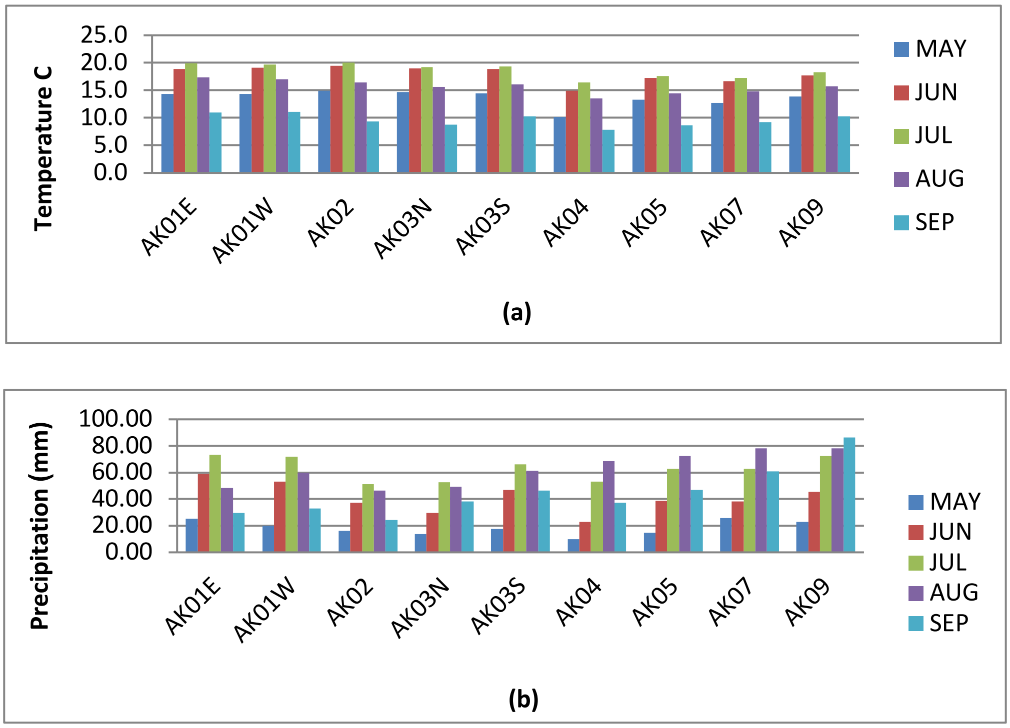


Figure 6. The spatial distribution of average seasonal temperature (a) and precipitation (b) from May to September over Interior Alaska from 1994-2017.

Monthly climatologies for temperature and precipitation indicate a strong seasonality for all of the PSAs in Boreal Alaska. Temperature and precipitation from May-September at the 9 Boreal PSAs are shown in Figure 6 (Table A-1, Appendix). The temperature seasonality is similar in all PSAs (Fig. 6a) and is consistent with the PSA averaged pattern shown in Figure 5a. When comparing the temperature between May, as the beginning of the summer season, and September, as the end of the summer season; average temperature is going up in May about 3 degrees more than September which is seen in the large temperature trends in May (Figure 5b). On the other hand, the seasonality of monthly mean precipitation (Fig. 6b) indicates that some PSAs receive the highest amount of precipitation in July and others in August. Also precipitation is higher in September than June in all PSAs, except in (AK01W), (AK01E), and (AK02). Precipitation reaches it seasonal maximum in September in Kuskokwim valley (AK09) (Fig.6b). It is notable that the largest trends over Boreal Alaska in precipitation are in September (Fig.5d). This suggests that other Boreal PSAs are starting to follow the seasonality of the (AK09) Kuskokwim valley.

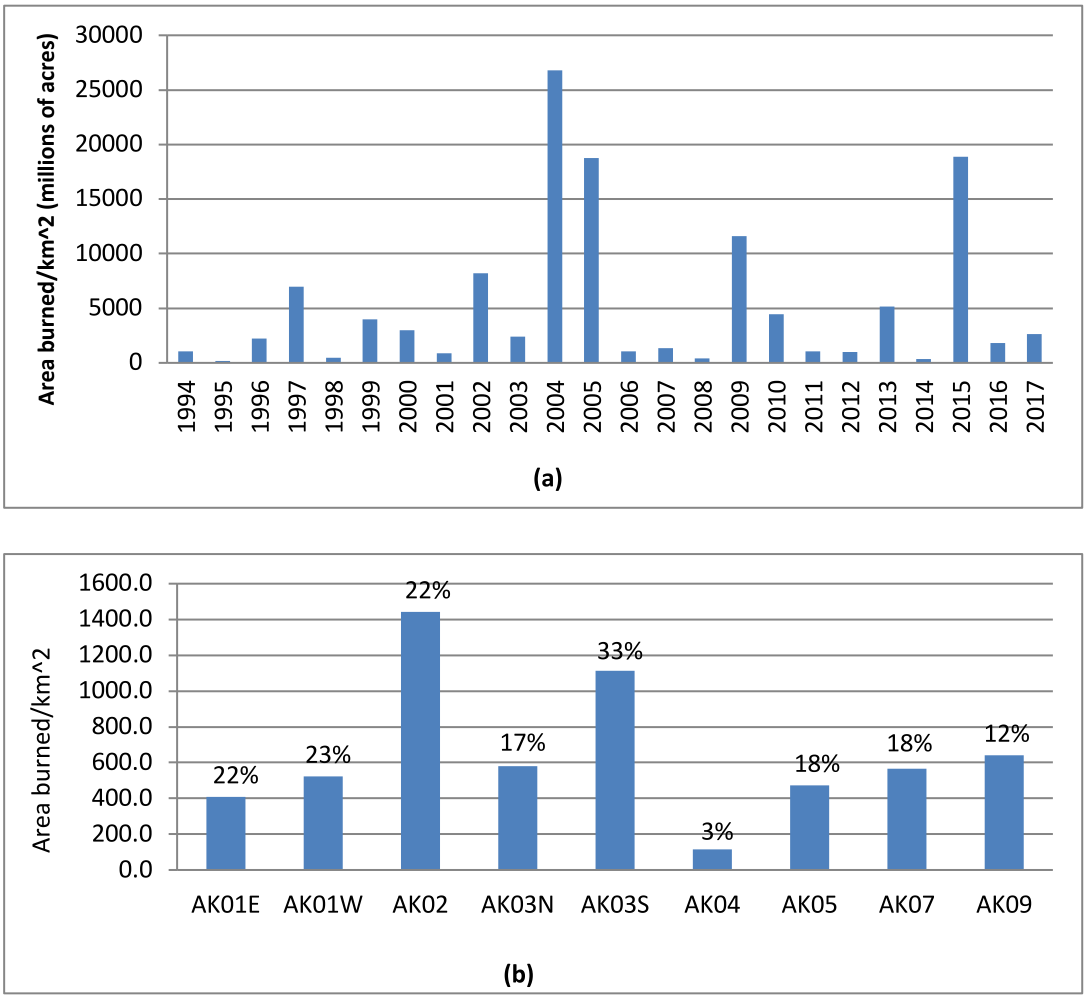


Figure 7. Area burned in Interior Alaska from 1994 – 2017. (a) Annual total area burned (km^2) from 1994 – 2017. (b) Average area burned (km^2) in each PSA. The number at the top shows what percentage the area burned is of the total PSA area.

The spatial and temporal distribution of the total area burned can be seen in Figure 7. The years 2004, 2015, 2005 and 2009 display the largest numbers of area burned (Fig. 7a). The largest fires were of the size of 26797 km^2 (6.6 million acres) in Interior Alaska in 2004. Summer 2004 was extremely warm and dry where the temperature reached the highest levels over the study record (21˚C) (Fig. A-1a, Appendix), and rainfall reached a record low of 102 mm. (Fig. A1-b, Appendix). Most of this rain came during thunderstorms (Rozell, 2004). Upper Yukon Valley (AK02) and Tanana Zone South (AK03S) are identified as the regions most exposed to wildland fire (Fig. 7b) as measured by total area burned (1441.2, 1112.4 km^2) and percent of total area burned (22%, 33%). Note that the largest values of area burned have occurred on the east-side of Interior Alaska. While, the smallest area of area burned is in the northwest part of area study and is known as the Upper Kobuk PSA (AK04).

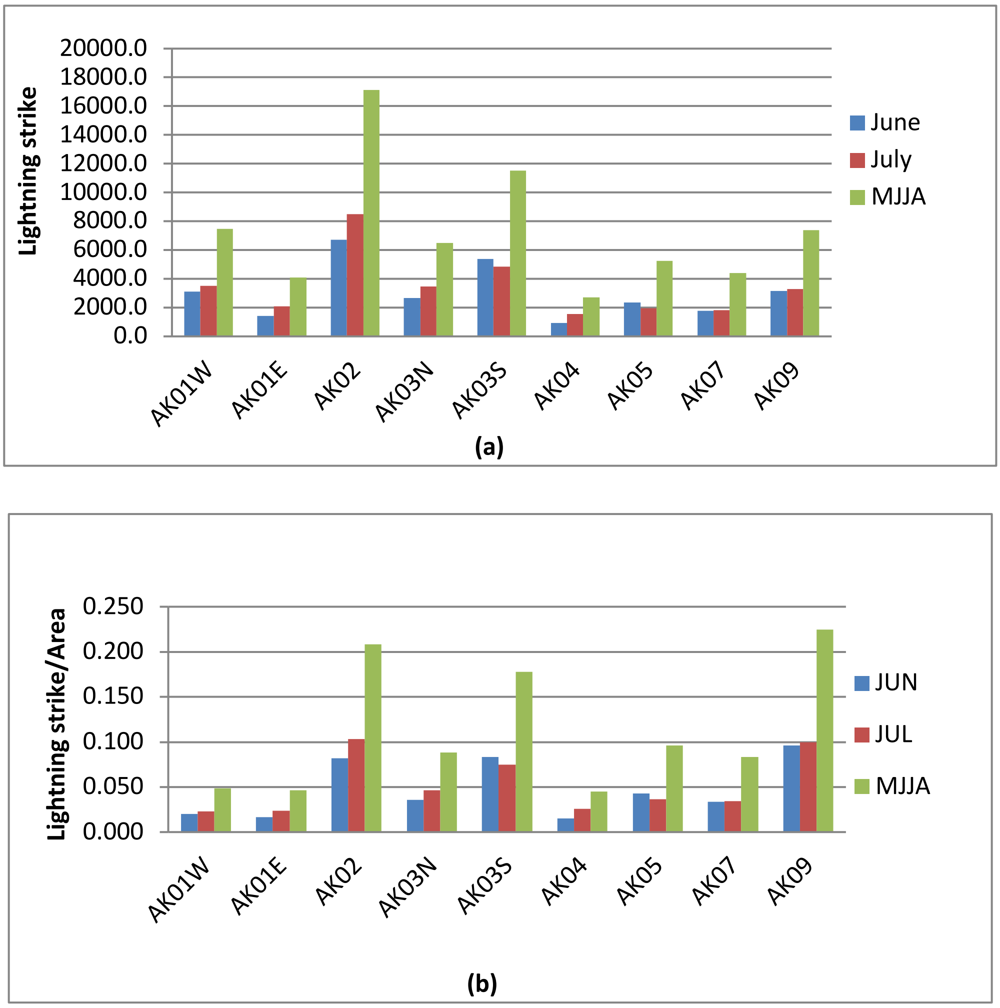


Figure 8. Lightning strike counts over the PSAs Interior Alaska (1994-2016). (a) Average number of lightning strikes. (b) The ratio of lightning strike to the total area of each PSAs.

The majority of area burned in Alaska are caused by lightning strikes (Waldman, 2017). Humans cause more fires but they are close to the road system and are more easily put out than remote fires. The largest number of lightning strikes over Interior Alaska occurs in the Upper Yukon valley (AK02) and Tanana Zone South (AK03S) (Fig. 8a). This is consistent with Fig. 7b which shows that the same PSAs have the greatest area burned. In contrast, the Upper Kobuk (AK04) experiences fewer wildfires (Fig. 7b) and has lower lightning counts compared to other PSAs

(Fig. 8a). To identify the strength between lightning strike and area burned, the correlation between them in June, July and summer season have been computed for all PSAs.

Table 2. Correlation coefficient between lightning strike and area burned in summer season MJJA, June and July in Boreal Interior, PSAs (1994-2016). The bold font shows strong correlation between variables.

Correlation	Area burned & lightning strikes					
	JUN		JUL		MJJA	
	R	%	R	%	R	%
AK01W	-0.11		0.13		0.09	
AK01E	-0.02		0.24		0.24	
AK02	0.16		-0.02		0.09	
AK03N	**0.39**	95	-0.04		0.16	
AK03S	**0.47**	99	0.27		**0.38**	95
AK04	0.06		0.00		-0.02	
AK05	**0.42**	97.5	0.32		**0.36**	90
AK07	-0.05		0.27		0.11	
AK09	0.24		0.10		0.20	

Table 2 indicates the relationship between lightning strike and area is weak in all PSAs except in Tanana Zone North (AK03N), Tanana Zone South (AK03S) and Middle Yukon (AK05) where there are positive correlations between 0.39 – 0.47 with a significance of 95 – 99% in June.

The spatial distribution of correlations between temperature, precipitation and area burned in the JJA summer season over Interior Alaska is shown in Table 3. Correlation coefficients measures the strength and direction of a linear relationship between these variables. It is noted that that correlation between **temperature and precipitation** is an inverse relationship (-0.4 to-0.59) with generally high significance ranging from 95 - 99.5% in most areas except in the Upper Kobuk (AK04).

In contrast, the relationship between **area burned and both temperature and precipitation** are varied and affected by location factors. While the statistical value associated with the relationship between temperature and area burned is strongly positive on the eastern side of Alaska (0.43 - 0.60) 97.5 - 99.5%, it is lower or almost disappearing on the west side as in Upper Kobuk (AK04), Tanana zone south (AK03S) and the Lower Yukon (AK07) (Fig. 9). Area burned and precipitation have a negative correlation ranging from (-0.36 - 0.46) which has significance ranging from 90 - 95%. The strongest correlation of -0.69 is in the Upper Yukon Valley (AK02) and attains a significance level of 99.5. Most of western side of the state shows a weak relationship (Fig. 9) between area burned and precipitation.

Table 3. Correlation coefficient between summer temperature, precipitation, and area burned in Boreal Interior, PSAs (1994-2017).

PSAs	**Summer Index**	JJA			
		Temperature		Precipitation	
		R	%	R	%
AK01E	Precipitation	-0.48	99		
	Area burned	0.60	99.5	-0.36	90
AK01W	Precipitation	-0.59	99.5		
	Area burned	0.43	97.5	-0.38	95
AK02	Precipitation	-0.56	99.5		
	Area burned	0.58	99.5	-0.69	99.5
AK03N	Precipitation	-0.48	99		
	Area burned	0.50	97.5	-0.40	95
AK03S	Precipitation	-0.40	95		
	Area burned	0.08	-	-0.07	-
AK04	Precipitation	-0.22	-		
	Area burned	0.08	-	0.10	-
AK05	Precipitation	-0.44	95		
	Area burned	0.33	90	-0.20	-
AK07	Precipitation	0.39	95		
	Area burned	0.21	-	-0.30	-
AK09	Precipitation	-0.45	97.5		
	Area burned	0.35	90	-0.46	95

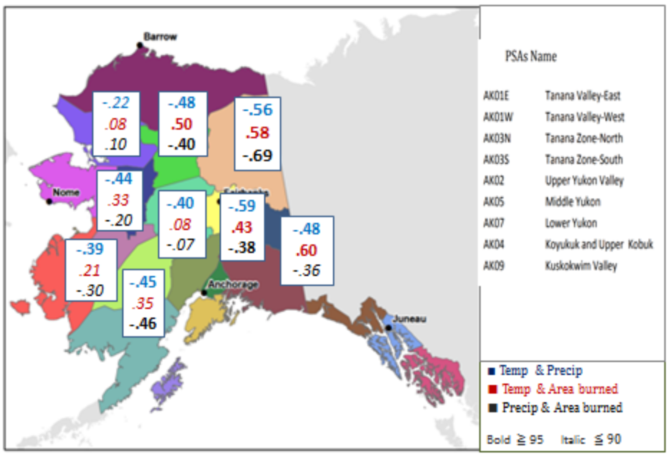
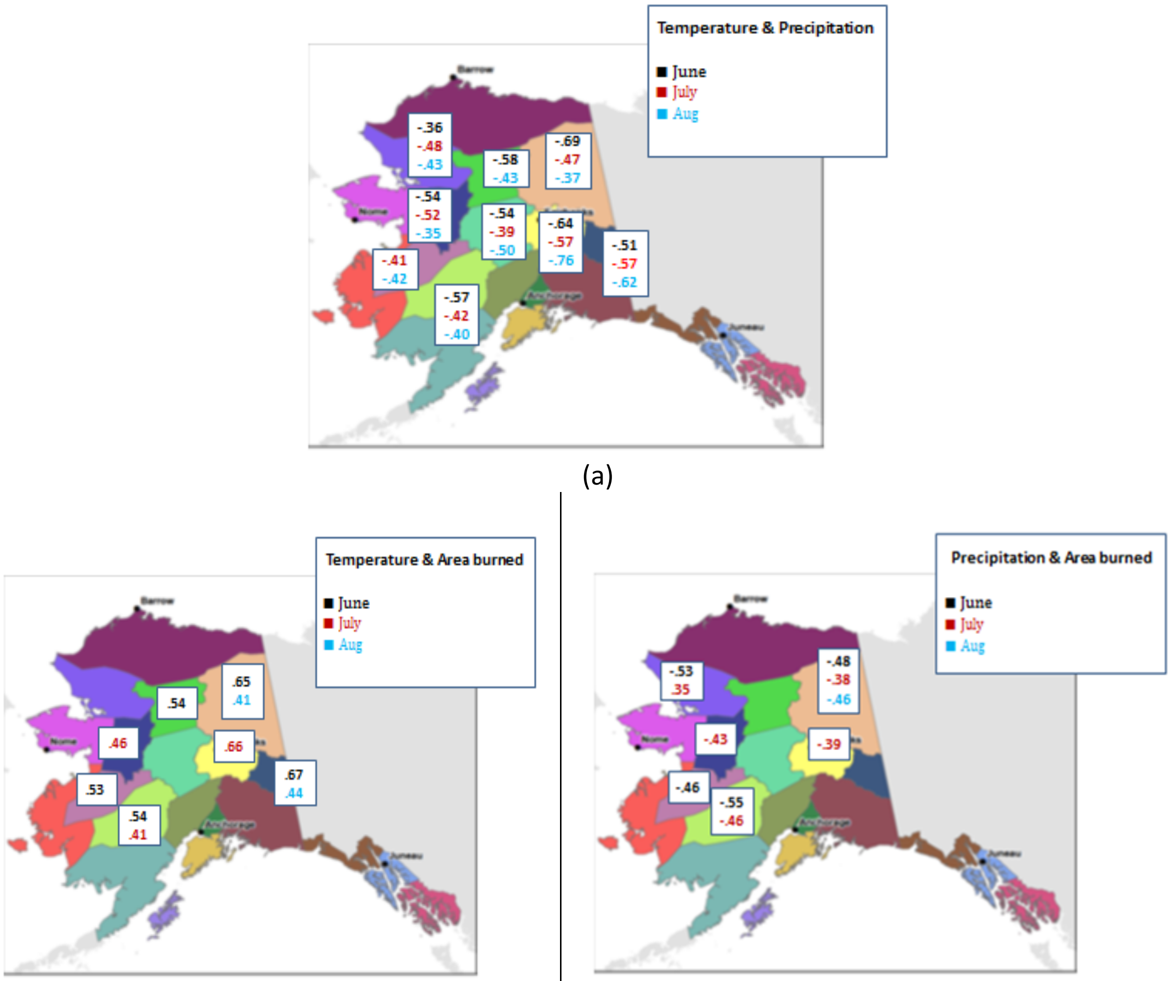


Figure 9. The correlation coefficient between summer (JJA) temperature, precipitation, and area burned in Boreal Interior (1994-2017) distributed on the map. Significance at the 95% level or greater is shown by values in bold.



(a)

(b)

(c)

Figure.10 (a) The significant negative correlation between summer temperature and precipitation. (b) Temperature and area burned. (c) Precipitation and area burned (1994-2017).

We next examine the **monthly relationship** between variables and identify the spatial and temporal distribution to determine the strength of the relationship for each month. The correlation between the variables was constructed for the transitional month of May, when spring ends and summer begins. Temperature conditions in May can have a bearing on the last day of snow cover (Figure 11). The disappearance of snow signifies the start of the fire season in Interior Alaska. Table 4 indicates that the relationships between temperature, precipitation and area burned are mostly weak for all of the PSAs. We note (AK09) has a strong correlation between the variables especially between temperature and area burned (0.44) 95%.

The relationship between the variables was found for June, July and August (see Table A-2, Appendix) for all PSAs and is shown in Figure 10. The correlation between **temperature and precipitation** in all PSAs is strongly negative in June, July and August ranging from -0.40 – 0.76 with significance of 95 - 99.5% except AK07 in June and AK03N in July. The relationship between **area burned and temperature** varies based on the summer month. In June the strength of a correlation between 0.53 - 0.67 with significance of 99- 99.5%, can be seen in AK01E, AK02, AK03N, AK07 and AK09. In July correlations range from 0.41 - 0.66 with significance of 95 - 99.5% in AK0W1, AK05, AK09. In August, there is no apparent relationship between the two variables except in AK0E1, AK02 (0.41 - 0.44) 95%. With respect to **area burned and precipitation**, the statistical significance ranges from (- 0.46 to - 0.55) 97.5 - 99.5% in AK02, AK04, AK07, AK09 and (-0.35 to - 0.46) 90 - 97.5% in AK02, AK01W, AK04, AK05, AK09 in June and July respectively, and significance almost disappears in all PSAs in August (Fig. 10c). In summary, it can be concluded that the correlation between variables is affected by location and varies throughout the summer.

Table 4. Correlation coefficient between temperature, precipitation, and area burned in May over Boreal Interior, PSAs (1994-2017). The bold font shows strong correlation between variables.

PSAs	Variables	May			
		Temperature		Precipitation	
		R	%	R	%
AK01E	Precipitation	**-0.54**	**99.5**		
	Area burned	0.15	-	0.13	-
AK01W	Precipitation	-0.05	-		
	Area burned	0.04	-	0.17	-
AK02	Precipitation	-0.25	-		
	Area burned	0.01	-	0.11	-
AK03N	Precipitation	-0.25	-		
	Area burned	0.16	-	**0.66**	**99.5**
AK03S	Precipitation	-0.18	-		
	Area burned	**0.30**	**90**	0.06	-
AK04	Precipitation	-0.15	-		
	Area burned	0.14	-	-0.13	-
AK05	Precipitation	**-0.36**	**95**		
	Area burned	0.15	-	0.19	-
AK07	Precipitation	0.04	-		
	Area burned	-0.12	-	**0.44**	**95**
AK09	Precipitation	**-0.34**	**90**		
	Area burned	**0.44**	**95**	**-0.36**	**90**

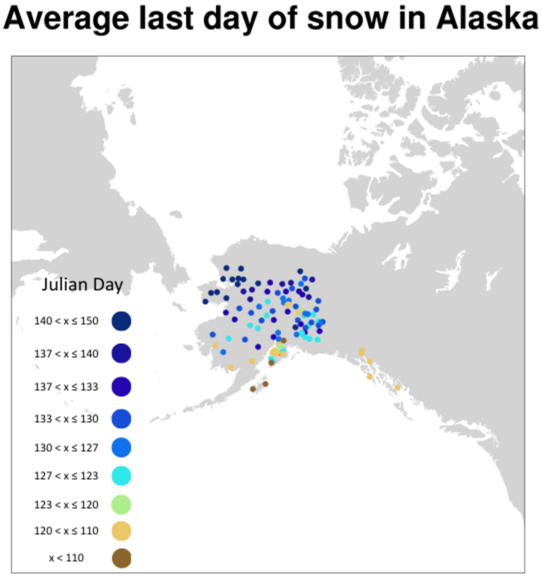


Figure 11. The average of the last day of snow throughout Alaska by using data from 23 stations from 1994 to 2015. This figure displays the last day of snow in Alaska distributed to nine categories based on Julian Day between 20 April (110) to 30 May (150).

Since the fires are influenced by warm season, it is important to analyze the summer months separately. Figure 12 shows the relationship by month between area burned in a given month, temperature and precipitation in June, July, and August respectively. Note this analysis is conducted for a shorter data set covering 1994-2017 because daily values only go back this far. It was found that the largest acreage burned was associated with the drier and hotter years such as 2015, 2004, 2009, 2005. Over the study period, it was found that the highest amount burned is in July (79935), which is twice the amount burned in June (33714) and August (32714). June is considered the drier month (370 mm). The correlation between temperature, precipitation, and area burned in June, July and August over Interior Alaska (Table.5) indicates that there are strong relationships between the variables especially in June and July while the relationship between precipitation, and area burned is stronger in August (-0.53) 97.5%.

Table 5: The relationship between Area burned, Temperature and Precipitation, JJA, in Interior of Alaska from 1994-2017.

Summer correlation	Temperature& Precipitation		Temperature & Area burned		Precipitation & Area burned	
	R	%	R	%	R	%
JUN	**-0.63**	99.5	0.41	95	**-0.37**	90
JULY	**-0.552**	99.5	**0.40**	95	**-0.27**	-
AUG	**-0.52**	97.5	**0.34**	90	**-0.53**	97.5

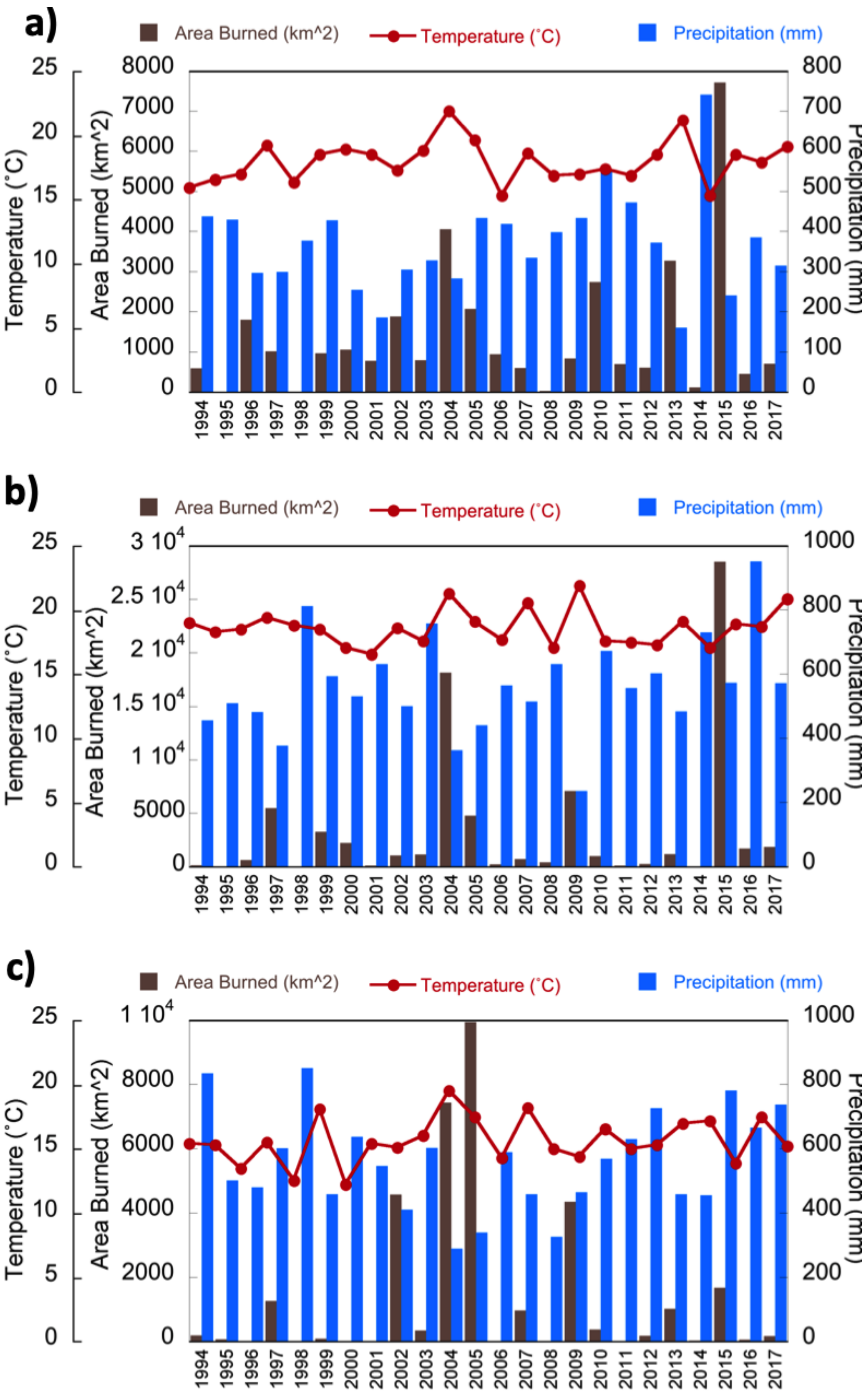


Figure 12. Area burned, Temperature and Precipitation over Interior Alaska from 1994-2017 a) June, b) July and c) August.

4. CONCLUSIONS

This study focused on the climate drivers of wildfire in Interior Alaska that occurred in summer season, JJA, during periods in 1994 to 2017. Analysis results presented in this paper provide identify links between meteorological variables and area burned, in the context of spatial and temporal variability at the PSA level.

The results summarized as follows:

1. Warmer temperatures caused higher chance of wildland fires as in summer 2004 (26797 km²) where the temperature reached the highest levels compared to all years of study. In addition, this study has shown that temperatures have the same seasonal cycle in all PSAs level; where the temperature increase begins in June, peaks in July and then gradually decline, consistent with the fire season.

2. Although precipitation limits the increase in forest fires, the accompanying lightning increases the chance fires which gives precipitation a double role in influencing the risk of fire. This can be seen clearly in both Upper Yukon valley (AK02) and Tanana Zone South (AK03S) where the largest number of lightning strikes over Interior Alaska occur (17000 and 11000 strikes, respectively). In addition, these two PSAs have the greatest area burned (1441.2 and 1112.4 km²).

3. There is an upward trend in both temperature and precipitation in all months especially in May and September which indicates a decline in the snow season and an increase in the length of the fire season.

4. A similar pattern was documented between PSAs in eastern versus western Alaska. Eastern PSAs receive the highest amount of precipitation in July, (AK01W, AK01E, AK02, AK03N, AK03S) , and western PSAs in August, (AK04, AK05, AK07).

5. The years 2004, 2015, 2005 and 2009 display the largest values for area burned with extremely warm and dry condition especially in 2004 with approximately 26797 km² (6.6 m acres).

6. The largest value for area burned occurred on the east-side of Interior Alaska [(AK01W) 23%, (AK01E) 22%, (AK02) 22%, (AK03S) 33%]. While, the smallest area of area burned is in Upper Kobuk PSA (AK04) 3%.

7. The correlation between temperature and precipitation in summer season, JJA, is an inverse relationship (-0.40 to -0.59) with generally high significance ranging

from 95 - 99.5% in most areas except in the Upper Kobuk (AK04). And in monthly season, June, July and August, ranging from (-0.40 to -0.76) 95 - 99.5% except AK07 in June and AK03N in July.

8. The correlation between area burned and both temperature and precipitation in summer season, JJA, is varied and affected by local factors; temperature and area burned has a strong positive correlation on the eastern side of Alaska (0.43 - 0.60) 97.5 - 99.5%, and weak or non-existent correlation on the west side of the state where area burned and precipitation have a negative correlation ranging from -0.36 to -0.46 (90 - 95%) with a weak relationship in western side.

9. There are strong correlations in the summer months of June and July between area burned and both temperature (0.41 - 0.67) 95 - 99.5% and precipitation (-0.35 to -0.55) 90 - 99.5%. The correlation is weak in August.

10. Future attempts to forecast area burned in Alaska should further investigate the identification of similarities and differences between PSAs according to geographical and topographical factors.

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APPENDIX A

Table A-1. Seasonal average in Interior Alaska from 1994- 2017 of a) temperature and b) precipitation. Temperature is shown in Celsius and precipitation in millimeters per month.

Temperature	MAY	JUN	JUL	AUG	SEP
AK01E	14.3	18.9	19.9	17.4	11.0
AK01W	14.3	19.1	19.7	17.0	11.0
AK02	14.9	19.4	20.1	16.4	9.3
AK03N	14.6	18.9	19.2	15.6	8.8
AK03S	14.5	18.8	19.3	16.1	10.3
AK04	10.2	15.0	16.5	13.5	7.8
AK05	13.3	17.2	17.6	14.5	8.7
AK07	12.7	16.7	17.2	14.8	9.3
AK09	13.8	17.8	18.3	15.7	10.2
Ave	13.6	18.0	18.6	15.7	9.6

(a)

Precipitation	MAY	JUN	JUL	AUG	SEP
AK01E	25.40	59.18	73.41	48.51	29.46
AK01W	19.81	53.09	72.14	59.94	33.02
AK02	16.26	37.08	51.05	46.23	24.38
AK03N	13.97	29.46	52.58	49.28	38.10
AK03S	17.78	46.99	66.04	61.21	46.48
AK04	9.65	23.11	53.34	68.58	37.08
AK05	14.48	38.61	62.99	72.39	46.74
AK07	25.65	38.10	62.74	77.98	60.96
AK09	23.11	45.47	72.39	77.98	86.36
Ave	18.46	41.23	62.96	62.46	44.73

(b)

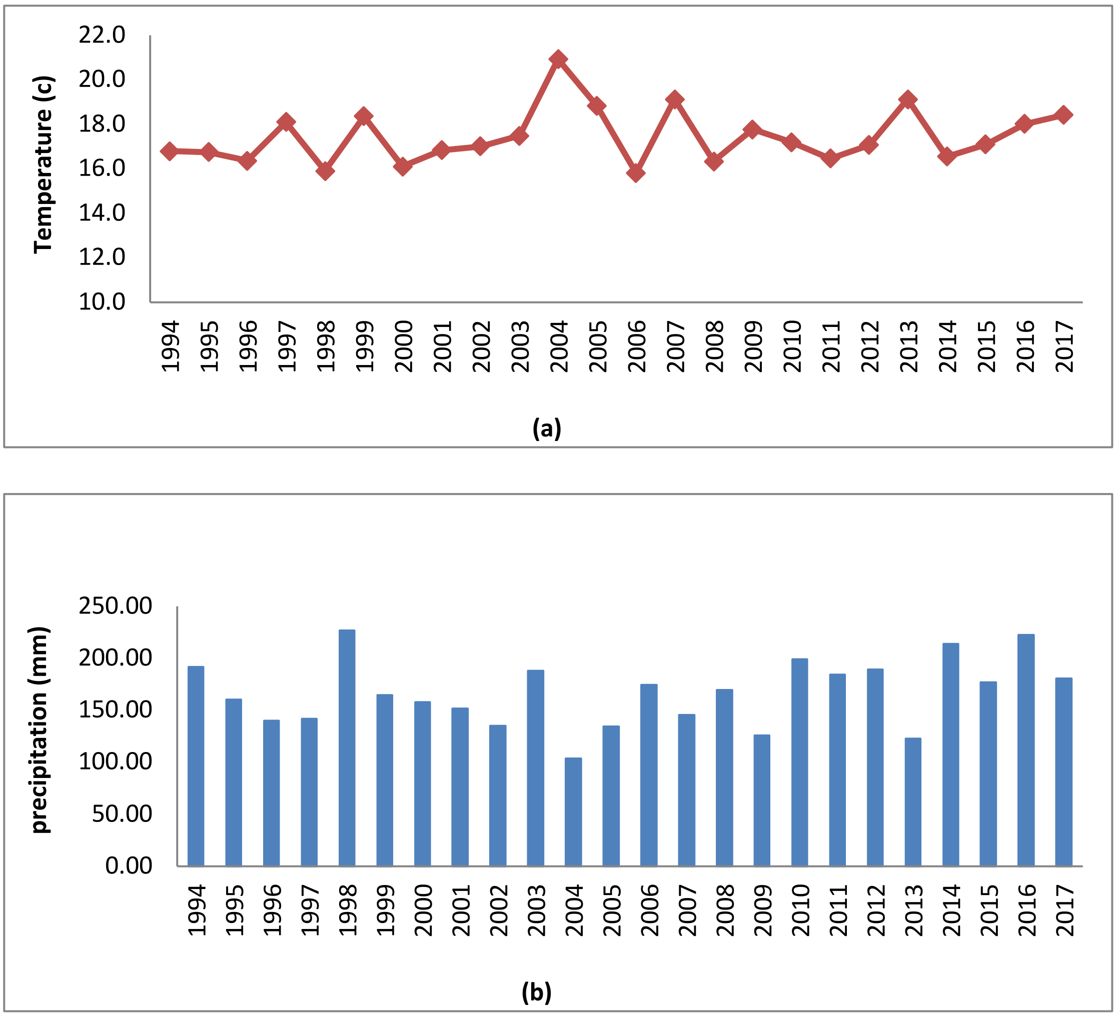

Figure A-1. Annual average Temperature (a) and precipitation (b) over study area (average of Interior Alaska PSAs) from 1994 – 2017.

TableA-2. Correlation coefficient between summer temperature, precipitation, and area burned in each interior Alaska PSAs (1994-2017). Area burned in this analysis is for the entire summer.

			Temperature		Precipitation	
			R	%	R	%
AK01E	JUN	Precipitation	-0.51	99		
		Area burned	0.67	995	-0.12	-
	JUL	Precipitation	-0.57	995		
		Area burned	0.25	-	-0.37	90
	AUG	Precipitation	-0.62	995		
		Area burned	0.44	95	-0.25	-
AK01W	JUN	Precipitation	-0.64	995		
		Area burned	0.29	-	-0.12	-
	JUL	Precipitation	-0.57	995		
		Area burned	0.66	995	-0.39	95
	AUG	Precipitation	-0.76	995		
		Area burned	0.12	-	-0.15	-
AK02	JUN	Precipitation	-0.69	995		
		Area burned	0.65	995	-0.48	99
	JUL	Precipitation	-0.47	99		
		Area burned	0.22	-	-0.38	95
	AUG	Precipitation	-0.37	95		
		Area burned	0.41	95	-0.46	975
AK03N	JUN	Precipitation	-0.58	995		
		Area burned	0.54	99	-0.26	-
	JUL	Precipitation	-0.26	-		
		Area burned	0.30	-	-0.38	90
	AUG	Precipitation	-0.43	975		
		Area burned	0.26	-	-0.18	-
AK03S	JUN	Precipitation	-0.54	995		
		Area burned	0.17	-	-0.19	-
	JUL	Precipitation	-0.39	95		
		Area burned	0.25	-	-0.01	-
	AUG	Precipitation	-0.50	99		
		Area burned	-0.17	-	0.06	-
AK04	JUN	Precipitation	-0.36	95		
		Area burned	0.27	-	-0.53	99
	JUL	Precipitation	-0.48	99		
		Area burned	-0.17	-	0.35	95
	AUG	Precipitation	-0.43	975		
		Area burned	0.10	-	0.08	-
AK05	JUN	Precipitation	-0.54	995		
		Area burned	0.28	-	-0.01	-
	JUL	Precipitation	-0.52	995		
		Area burned	0.46	975	-0.43	975
	AUG	Precipitation	-0.35	95		
		Area burned	0.03	-	0.01	-

Continued Table A-2. Correlation coefficient between summer temperature, precipitation, and area burned in each interior Alaska PSAs (1994-2017).

			Temperature		Precipitation	
			R	%	R	%
AK07	JUN	Precipitation	-0.19	-		
		Area burned	0.53	99	-0.46	975
	JUL	Precipitation	-0.41	975		
		Area burned	0.22	-	-0.36	90
	AUG	Precipitation	-0.42	975		
		Area burned	-0.01	-	-0.16	-
AK09	JUN	Precipitation	-0.57	995		
		Area burned	0.54	975	-0.55	975
	JUL	Precipitation	-0.42	975		
		Area burned	0.41	95	-0.46	95
	AUG	Precipitation	-0.40	95		
		Area burned	-0.06	-	-0.07	-

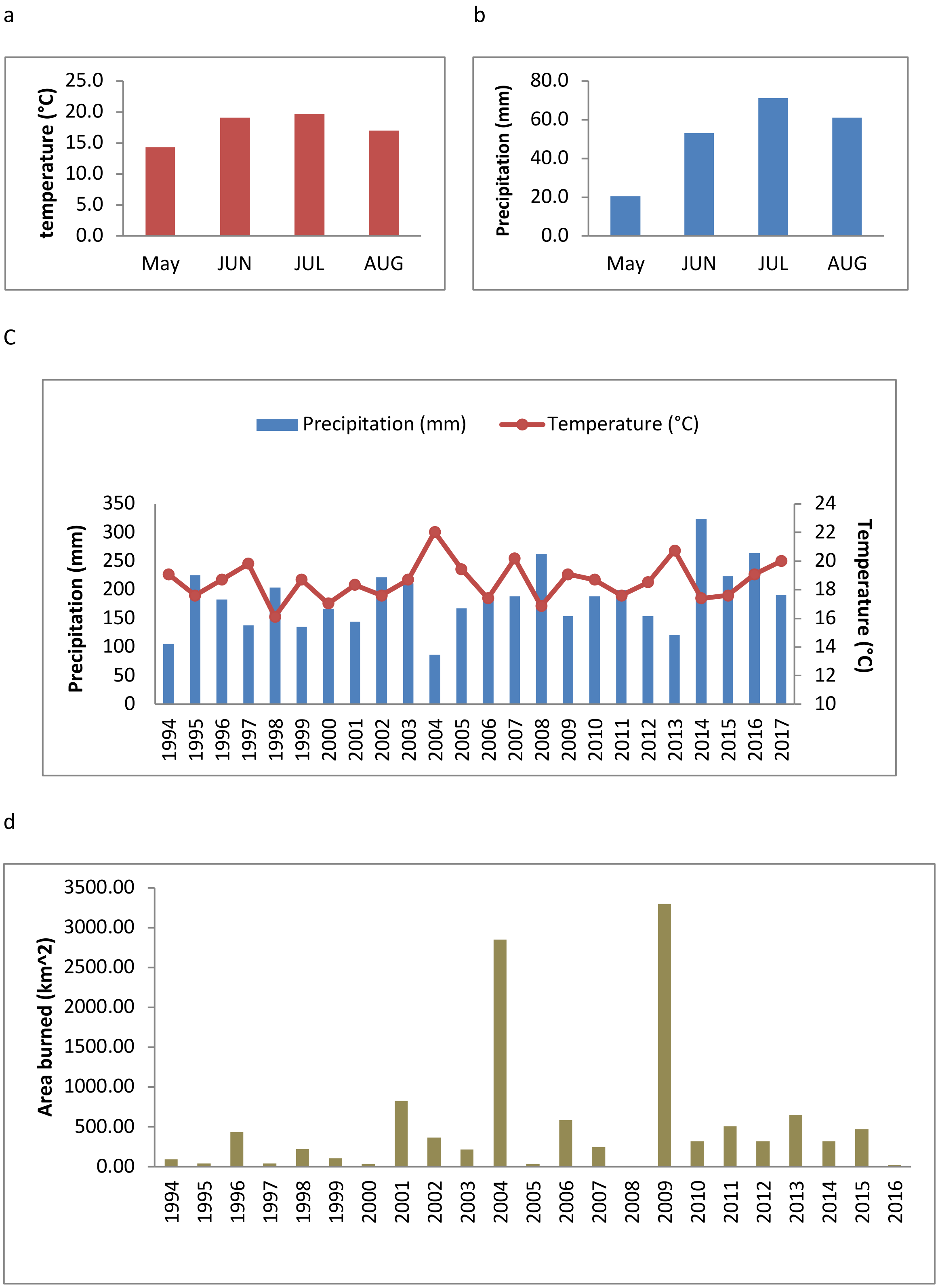

Figure A-2. Temperature, precipitation and area burned data for **Tanana Valley West, AK01W**, from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).

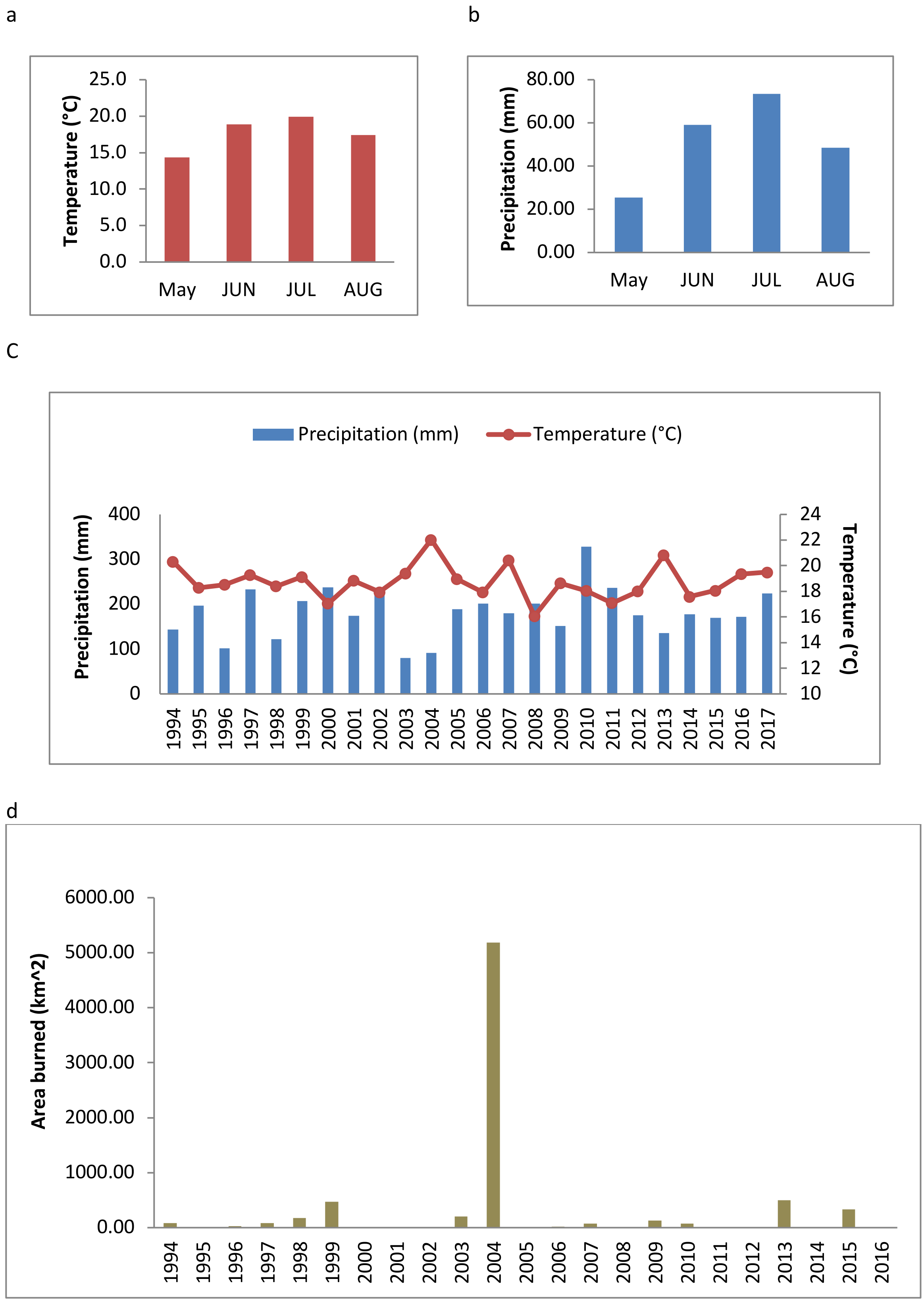

Figure A-3. Temperature, precipitation and area burned data for **Tanana Valley East, AK01E**, from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).

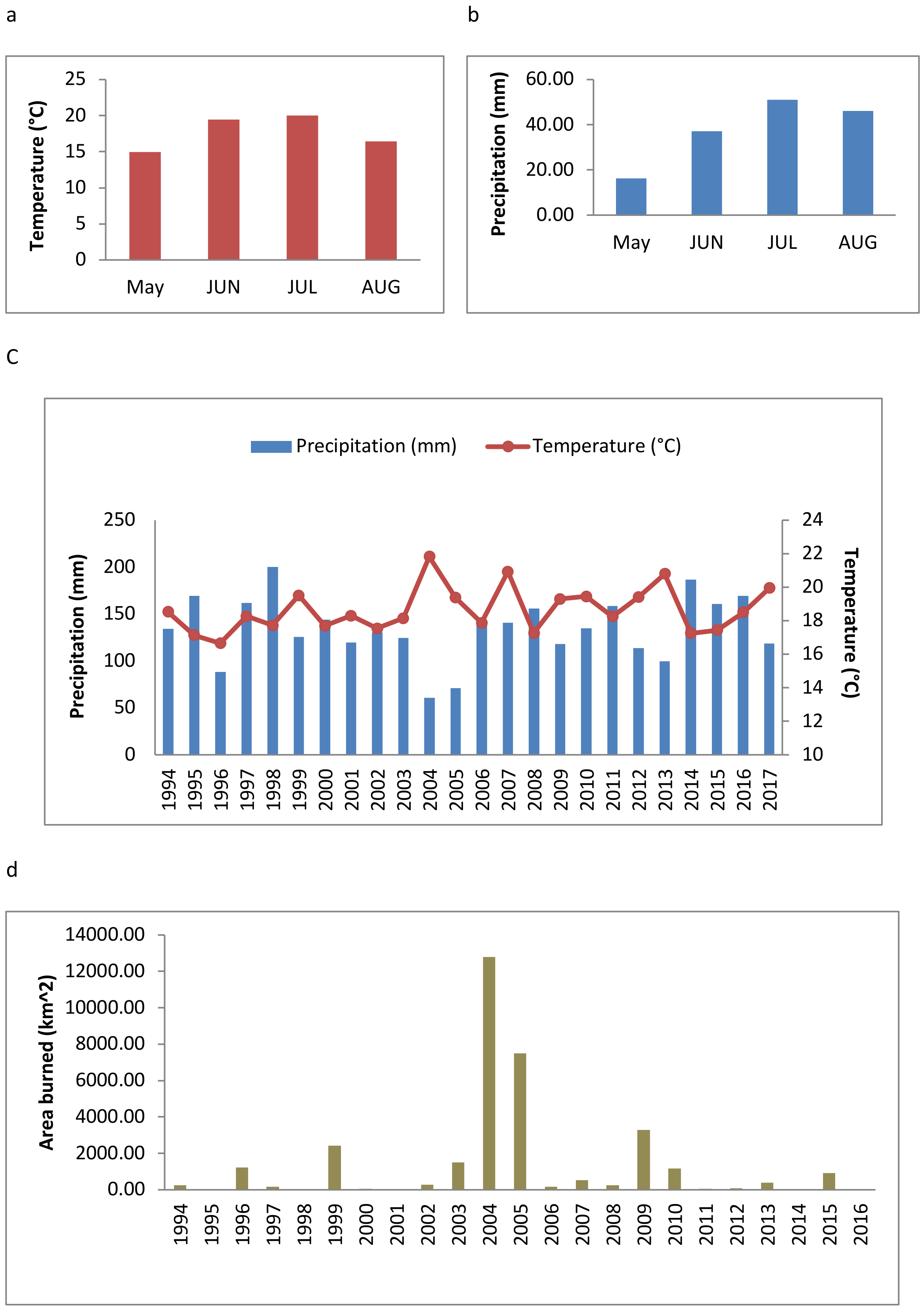

Figure A-4. Temperature, precipitation and area burned data for **Upper Yukon Valley, AK02,** from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).

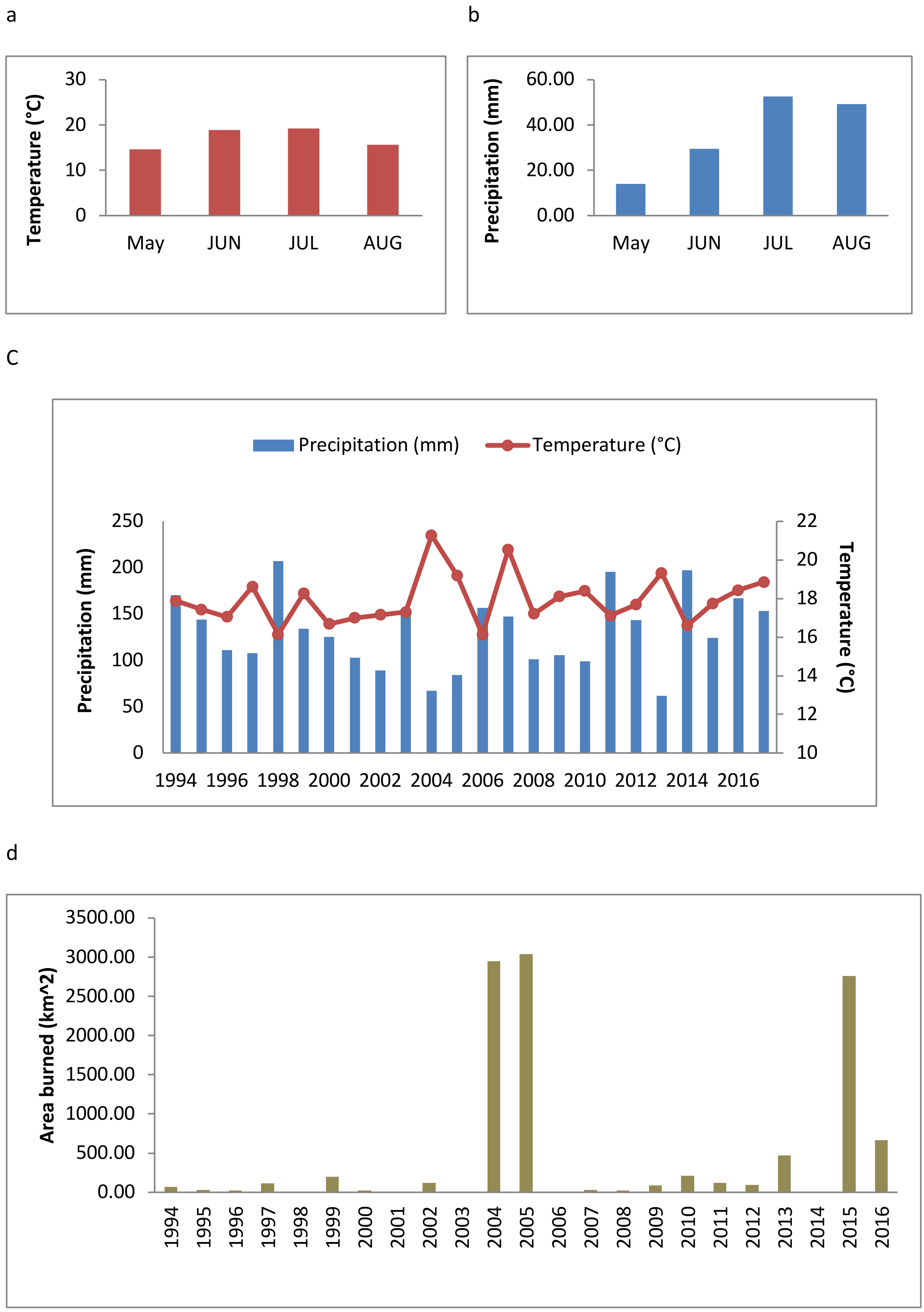

Figure A-5. Temperature, precipitation and area burned data for **Tanana Zone North, AK03N,** from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).

a b

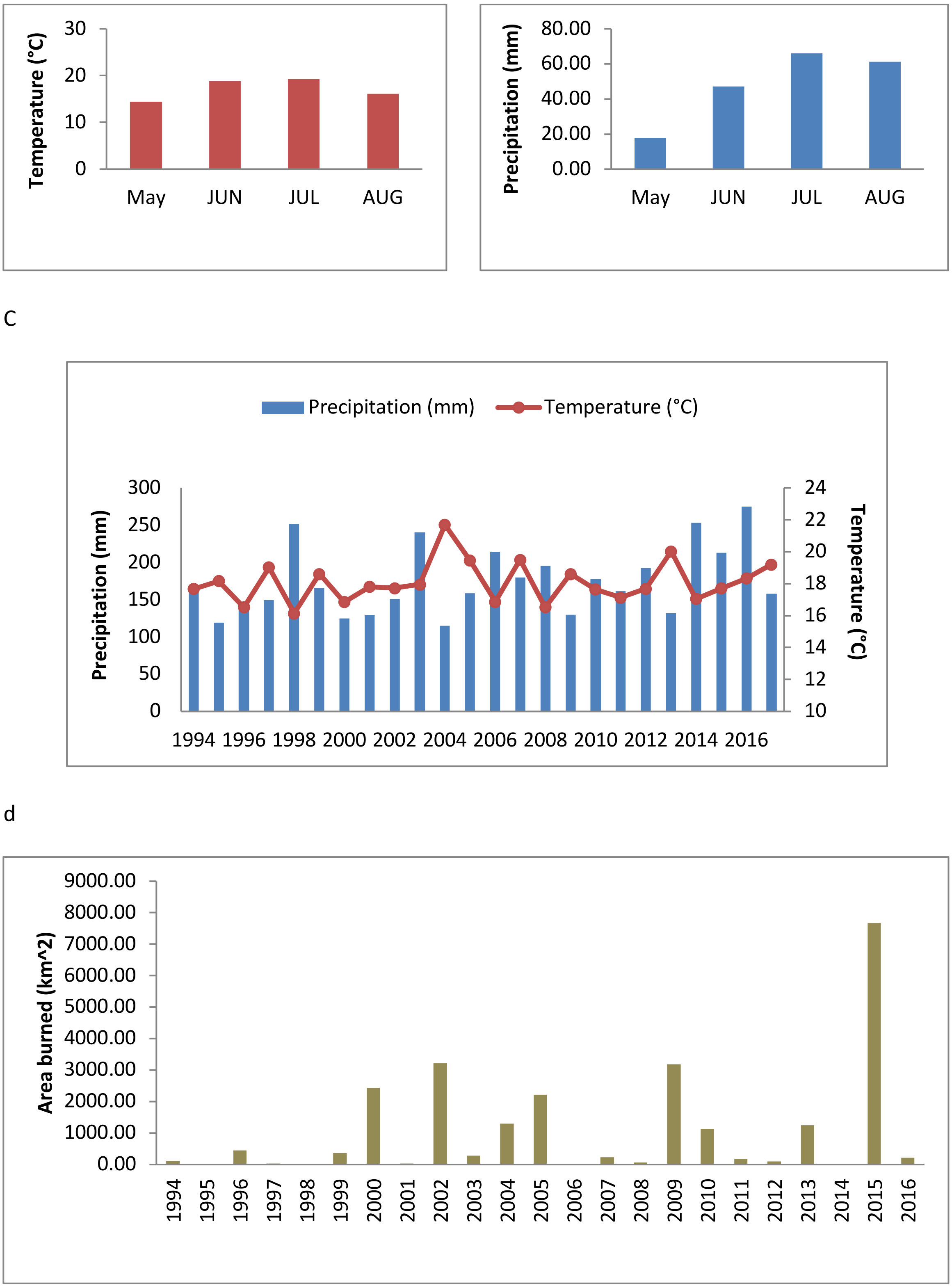

Figure A-6. Temperature, precipitation and area burned data for **Tanana Zone South, AK03S,** from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).

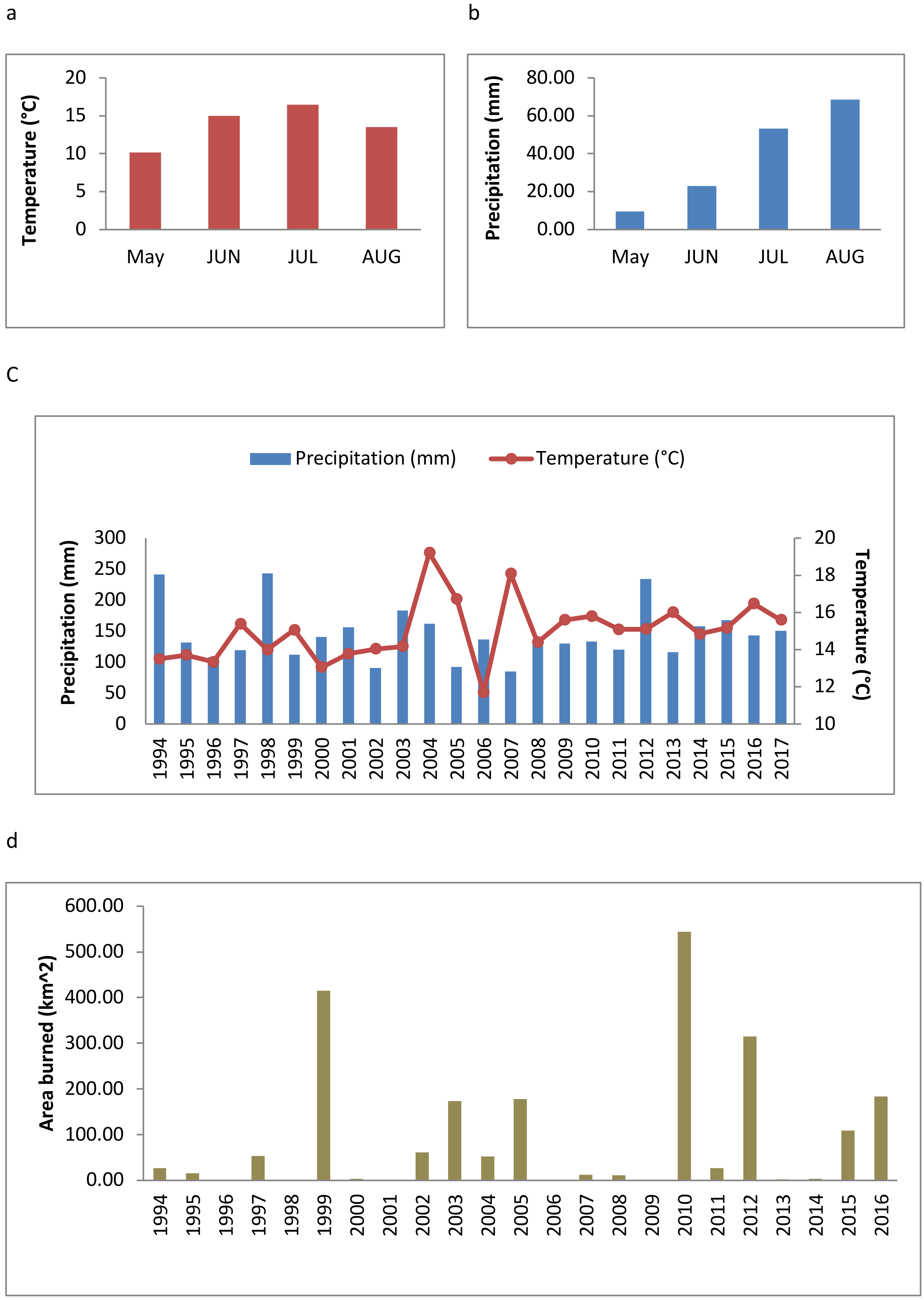

Figure A-7. Temperature, precipitation and area burned data for **Upper Kobuk, AK04,** from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).

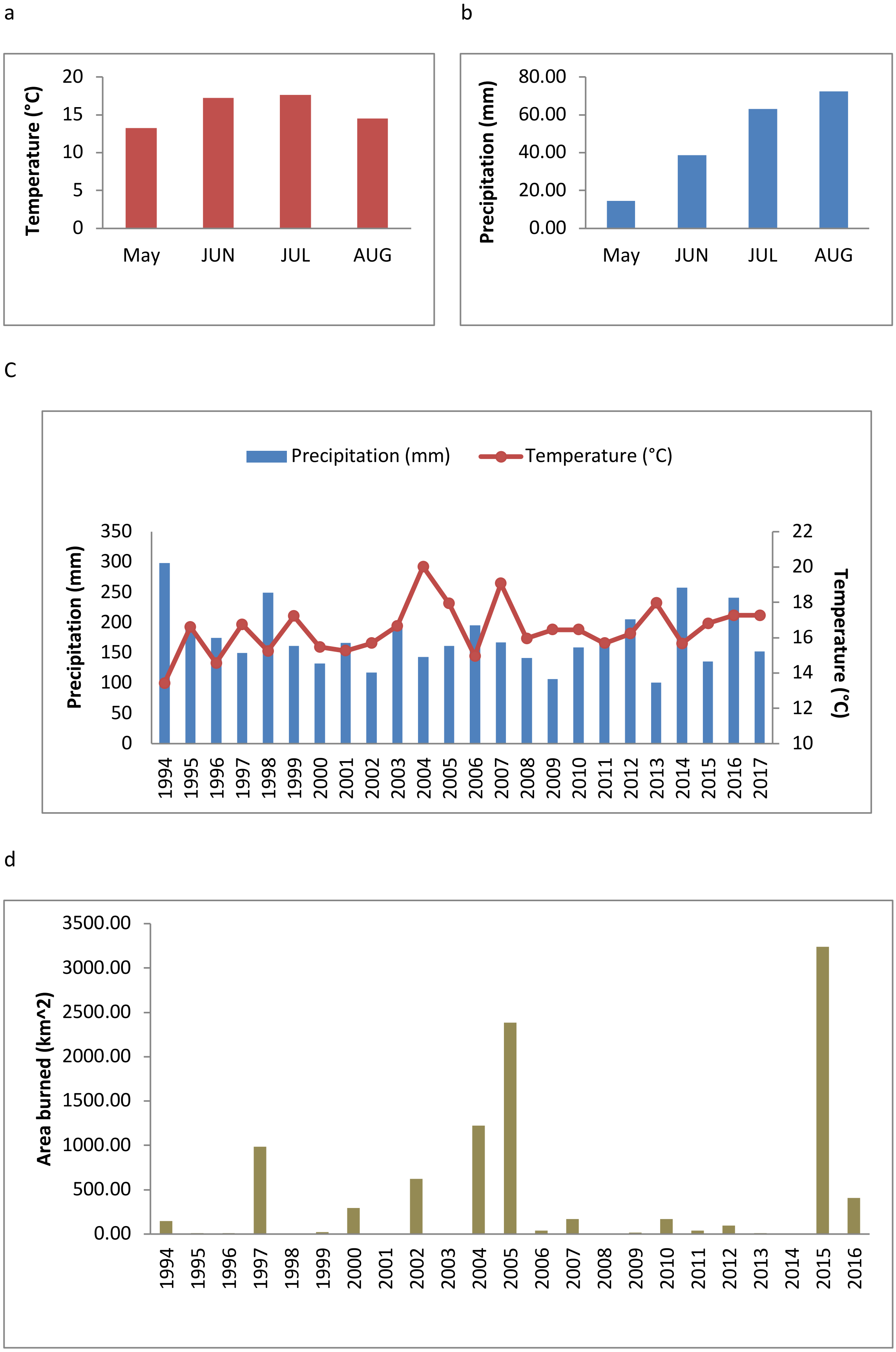

Figure A-8. Temperature, precipitation and area burned data for **Middle Yukon, AK05,** from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).

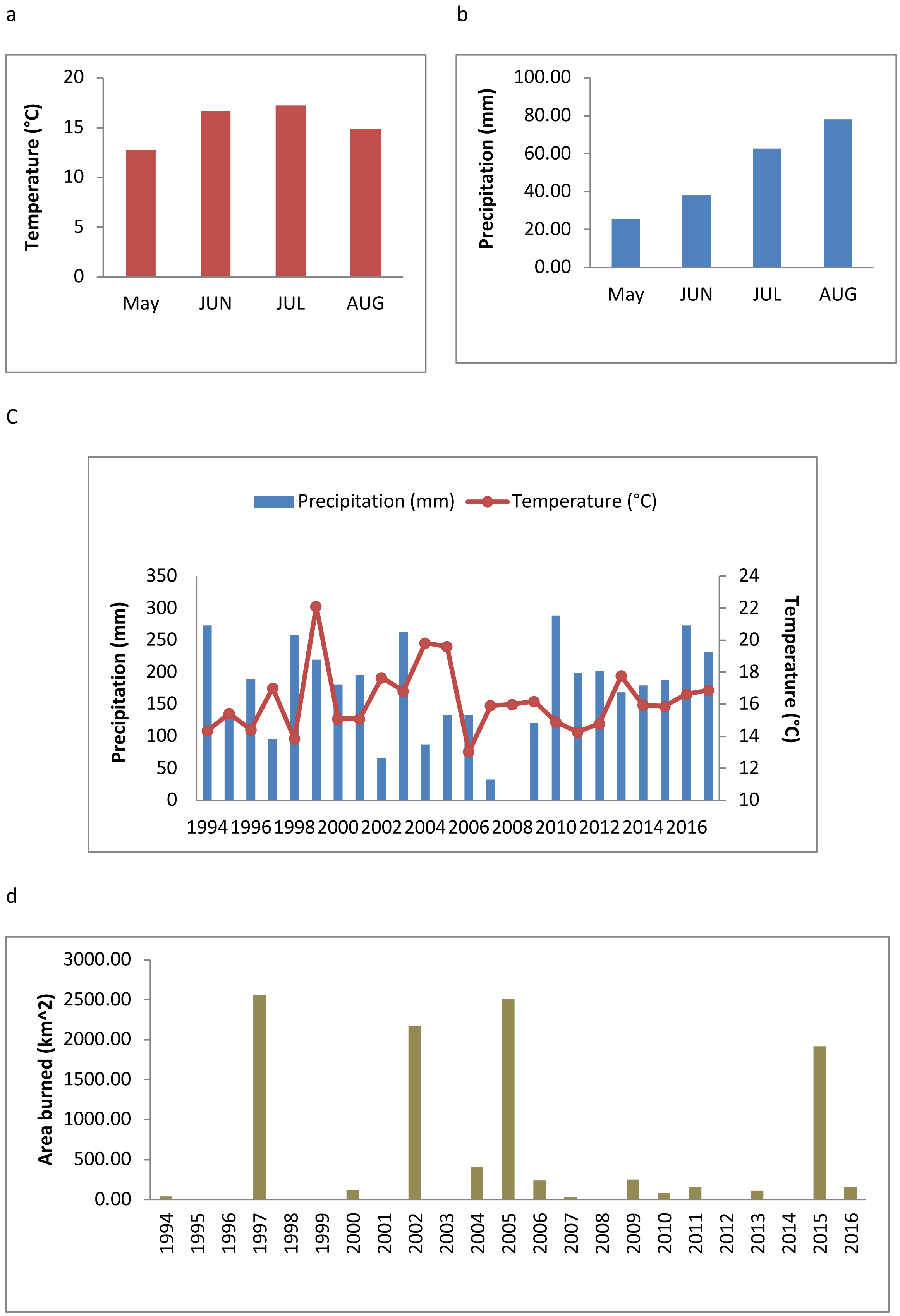

Figure A-9. Temperature, precipitation and area burned data for **Lower Yukon, AK07,** from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).

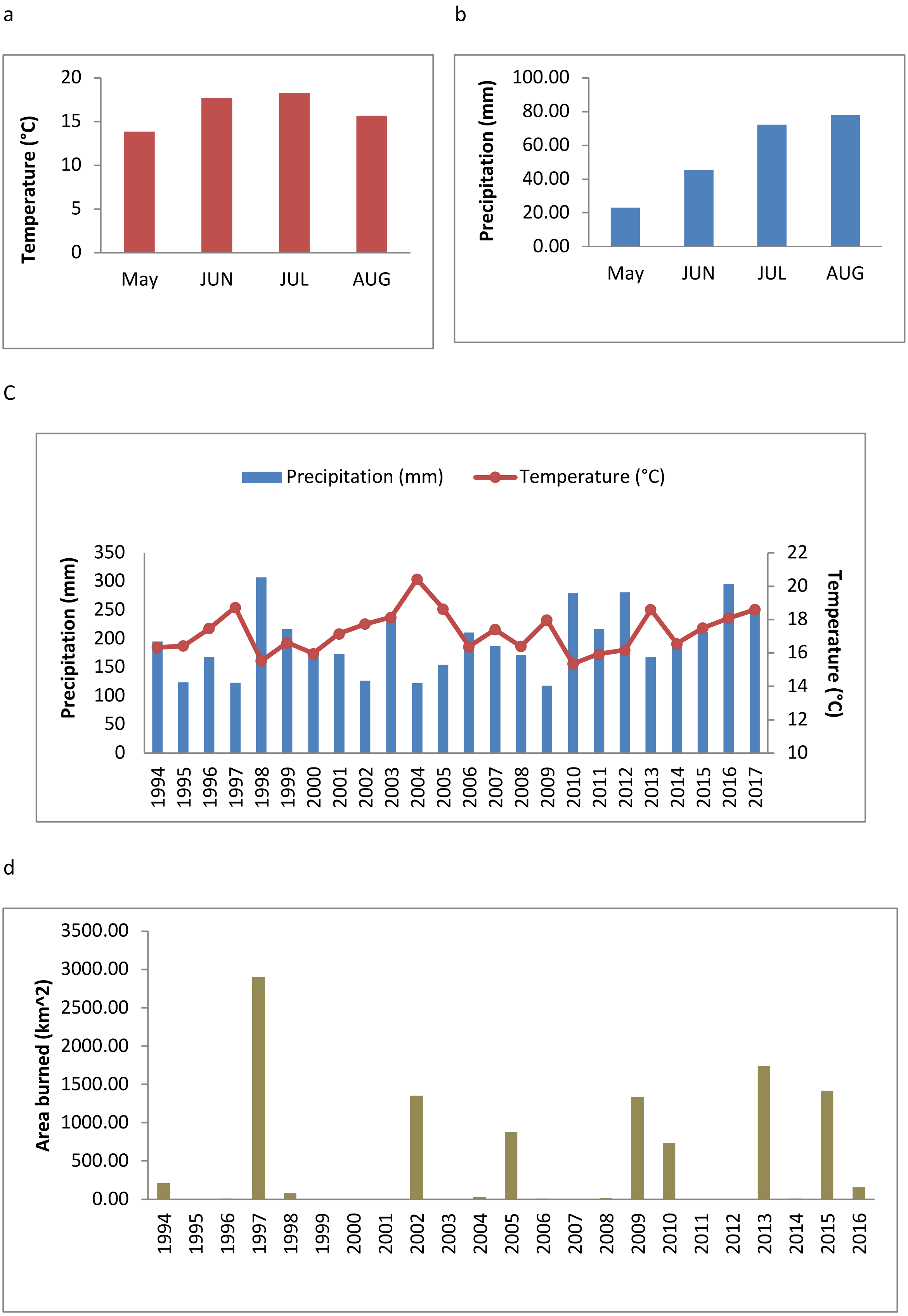

Figure A-10. Temperature, precipitation and area burned data for **Kuskokwim valley, AK09,** from 1994-2017. Summer climatological temperature (a) and Precipitation (b). Annual temperature and precipitation (c), and Area burned time series (d).