ModularityHW_Kelly

Michelle Kelly

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Abstract

(you will have to write this) climate change, long term trends, etc

Introduction

Average surface temperature on Earth has increased by 0.7°C since the onset of the industrial era (UNFCC report 2007). Widespread fossil fuel use, and the following spike in atmospheric CO2, have acted as a global insulation blanket: trapping heat in the atmosphere and slowing it's release (Asfaw et al 2017). Increased temperatures are also impacting precipitation regimes; in the United States, increases in the severity of drought and flood events are expected (Dore, 2005). However, the impact of global change on a local level is expected to be more spatially heterogenous, with different regions of the US experiencing varied climate and precipitation responses (Trenberth 2011).

We assess these expectations using 50 years of weather station data, asking (1) can climate warming be seen across the United States, (2) are the effects of climate warming regionally-dependent, and (3) what change has occured in precipitation?

Methods

We used annualy averaged weather-station temperature (50 states, 15175 weather stations) and precipitation data (3 states, 2556 weather stations) from 1950 to 2008. Only weather stations with at least 40 years of measurement data were included in this analysis.

Yearly summary statistics were calculated by taking the mean observation within a state during any given year. To compare changes across time, a mean value for the duration of observations within a state was calculated, and subtracted from the annual value . Therefore, negative values represent time periods when a state was experiencing below average temperatures, and positive values represent periods when a state was experiencing above average temperatures.

$ Deviation from average_{state} = Annual average_{state} - Time series average_{state} $

Results

```
## Warning: package 'bindrcpp' was built under R version 3.4.4
```

```
##
## Call:
## lm(formula = precip_summary$mean ~ precip_summary$year)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -9.9291 -3.5361 -0.3979  4.0317 10.4042
```

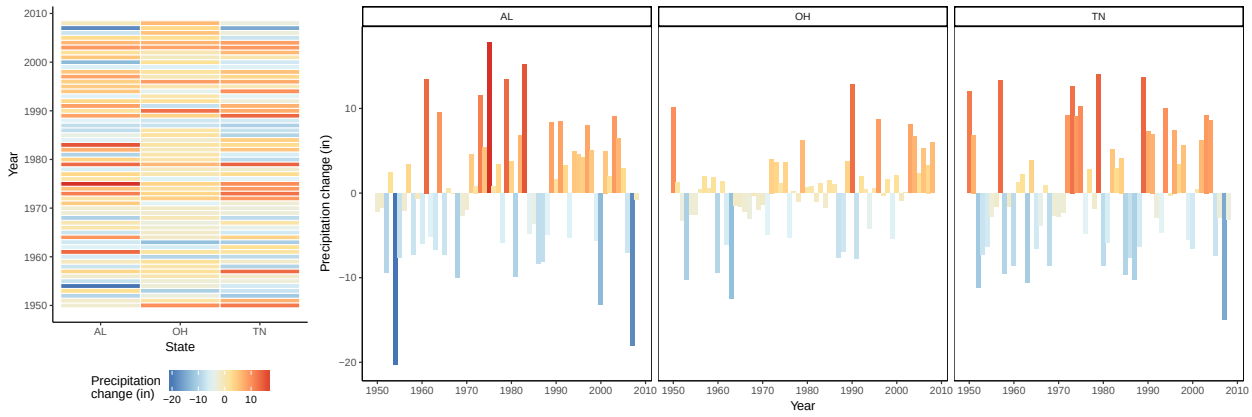

Figure 1: Anomalies in annual precipitation, relative to 1950-2008 state average

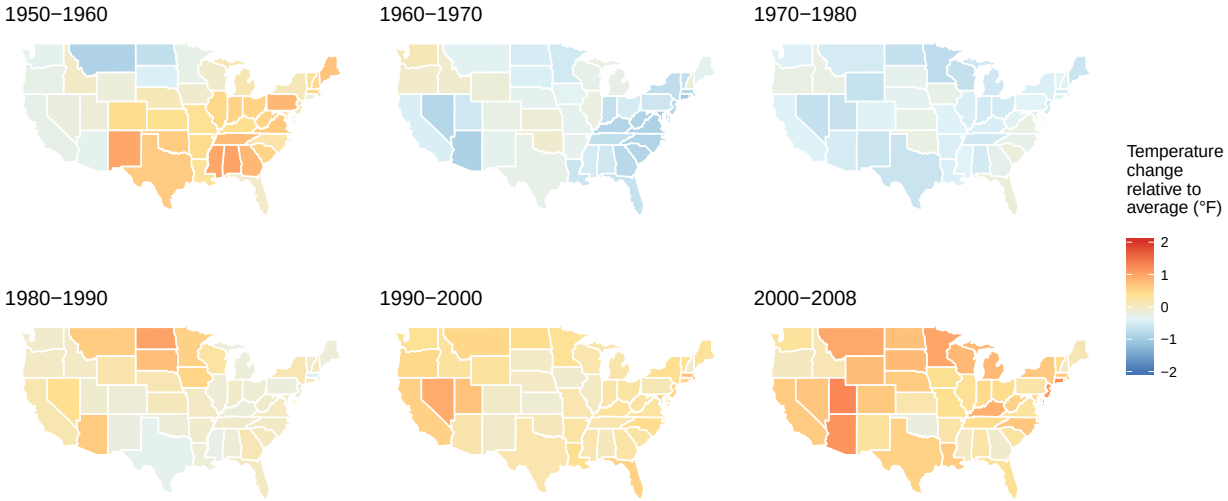

Figure 2: Average change in temperature over most recent decade (1998-2008), relative to 1950-2008 state average.

```
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)         -69.69219   78.97275  -0.882    0.381
## precip_summary$year   0.05936    0.03990   1.488    0.142
##
## Residual standard error: 5.22 on 57 degrees of freedom
## Multiple R-squared:  0.03737,    Adjusted R-squared:  0.02048
## F-statistic: 2.213 on 1 and 57 DF,  p-value: 0.1424
```

```
##
## Call:
## lm(formula = temp_summary$mean ~ temp_summary$year)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.30674 -0.52017 -0.01407  0.42385  1.65033
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)       35.355683  10.680781   3.310  0.00162 **
## temp_summary$year  0.008885   0.005397   1.646  0.10519
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7059 on 57 degrees of freedom
## Multiple R-squared:  0.0454, Adjusted R-squared:  0.02865
## F-statistic: 2.711 on 1 and 57 DF,  p-value: 0.1052
```

```
##
## Call:
## lm(formula = temp_state$change ~ temp_state$year)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4.5438 -0.7972 -0.0552  0.7536  4.5822
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)     -23.915792   2.456982  -9.734   <2e-16 ***
## temp_state$year   0.012085   0.001241   9.734   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.148 on 2948 degrees of freedom
## Multiple R-squared:  0.03114,    Adjusted R-squared:  0.03081
## F-statistic: 94.75 on 1 and 2948 DF,  p-value: < 2.2e-16
```

```
##
## Call:
## lm(formula = precip_state$change ~ precip_state$year)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -19.6646  -5.0764   0.2652   3.9255  18.0114
```

```
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)       -116.38765   59.07844   -1.97   0.0504 .
## precip_state$year    0.05881    0.02985    1.97   0.0504 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6.763 on 175 degrees of freedom
## Multiple R-squared:  0.0217, Adjusted R-squared:  0.01611
## F-statistic: 3.881 on 1 and 175 DF,  p-value: 0.0504
```

Discussion

References

Supplemental

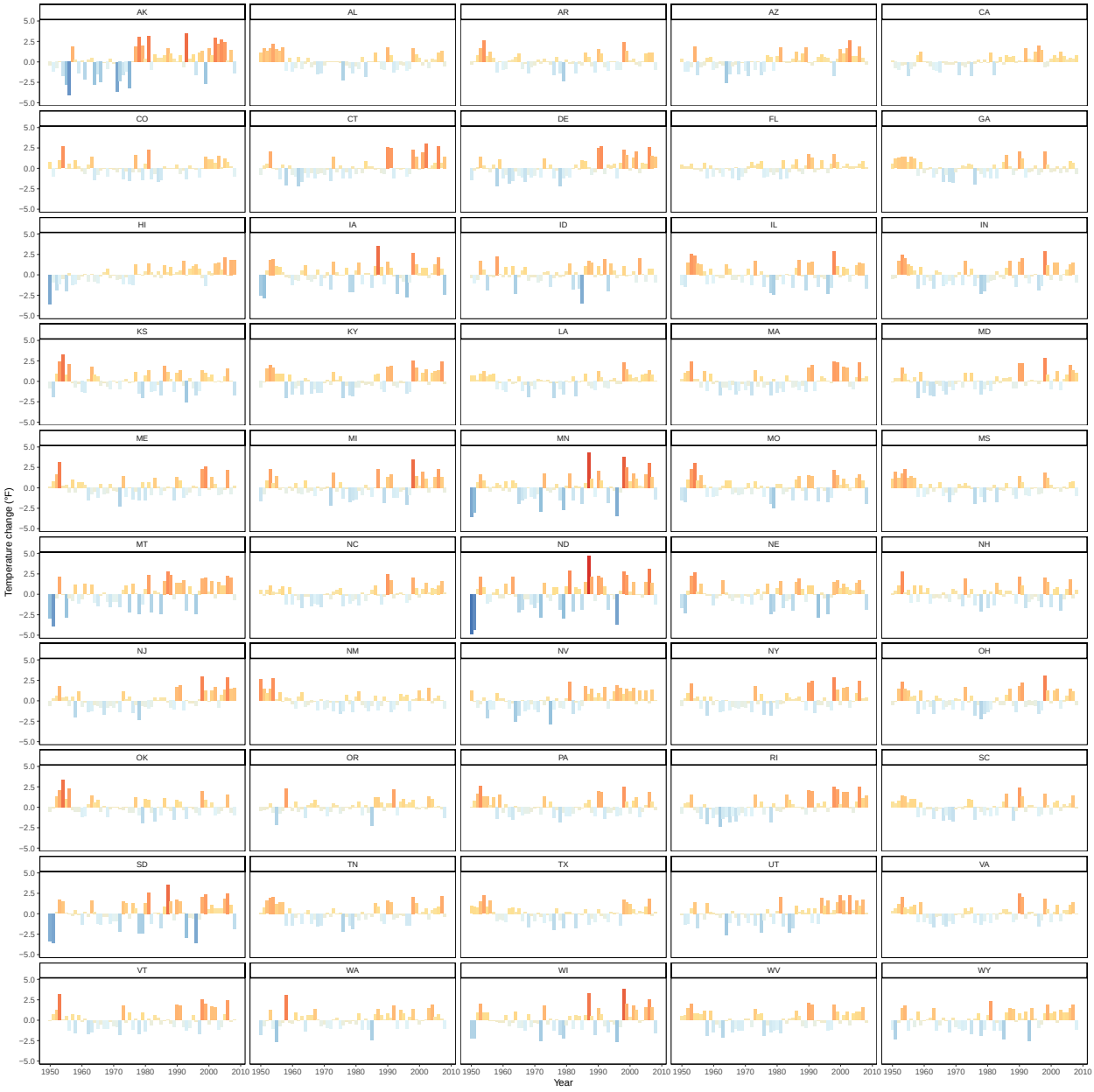

Figure 3: Anomalies in annual mean temperature, relative to 1950-2008 state average