United States' Climate Change Assessment

TOPIC OVERVIEW:

- Why do I choose this topic?
- Recent catastrophic events: fires in California and hurricane Laura.
- Why do I choose the following dataset?
- Provides a detailed overview of temperature and precipitation in the 49 states (except Hawaii)
- Provides inclusive information that are part of the climate assessment, “which is the weather conditions prevailing in an area in general or over a long period of time. ” – Oxford Languages
- Project Objective:
- To evaluate whether climate change is happening within 49 states in the U.S by looking at the two main variables temperature and precipitation from 1895 to 2020. If so, which states are experiencing the change?

Original Dataset overview:

	year	month	day	date	tAL	pAL	tAK	pAK
1	1895	1	25	01/25/1895	43.1	7.52	2.05	3.025
2	1895	2	25	02/25/1895	37.4	2.66	-0.20	1.655
3	1895	3	25	03/25/1895	54.5	7.62	15.70	2.865
4	1895	4	25	04/25/1895	63.4	3.58	25.90	2.270
5	1895	5	25	05/25/1895	69.5	3.78	38.65	2.135
6	1895	6	25	06/25/1895	77.5	5.79	50.50	2.020
7	1895	7	25	07/25/1895	79.2	4.51	52.65	3.210
8	1895	8	25	08/25/1895	79.5	5.13	51.30	3.335
9	1895	9	25	09/25/1895	77.8	1.60	43.55	5.810
10	1895	10	25	10/25/1895	59.7	2.22	31.65	5.530
11	1895	11	25	11/25/1895	53.2	1.76	16.95	3.580
12	1895	12	25	12/25/1895	44.9	4.23	2.05	3.850
13	1896	1	25	01/25/1896	43.5	4.33	6.75	3.400
14	1896	2	25	02/25/1896	47.7	6.16	10.05	3.105
15	1896	3	25	03/25/1896	52.5	5.44	4.05	2.645
16	1896	4	25	04/25/1896	68.0	3.54	19.15	1.695
17	1896	5	25	05/25/1896	75.9	3.24	36.90	1.870
18	1896	6	25	06/25/1896	77.4	5.44	49.40	2.390
19	1896	7	25	07/25/1896	81.2	4.99	52.80	3.490

Showing 1 to 23 of 1,507 entries, 102 total columns

- Source: NOAA (Link: https://www.ncdc.noaa.gov/cag/statewide/time-series)
- Variables:
  - Date (same date, months, and years from 1985-2020) assigned as mm/dd/yyyy
  - Temperature(49 states) assigned as t(state abbreviations) in Fahrenheit
  - Precipitation (49 states) assigned as p(state abbreviations) in Inches
  - library(readxl) – used to read file
  - library(lubridate)(tidyverse)(dplyr) – used to sort the column date into separate year, month, day to create a subset for average calculation.
  - 102 columns x 1507 rows

```
> df %>%
+   mutate(
+     dates2=ymd(test.date), # convert to Date type using lubridate
+     year=year(dates2), # extract parts
+     month=month(dates2),
+     day=day(dates2)
+   )
# A tibble: 1,507 x 5
   a          dates2      year month   day
   <date>     <date>     <dbl> <dbl> <int>
 1 1895-01-25 1895-01-25  1895     1    25
 2 1895-02-25 1895-02-25  1895     2    25
```

DATA"SUBSET" OVERVIEW:

```
> avg<- aggregate(tp[, 5:102], list(tp$year), mean)
> write.csv(avg, "avg.csv")
> view(avg)
```

	Group.1	tAL	pAL	tAK	pAK	tAZ	pAZ	tAR	pAR	tCA
1	1895	61.64167	4.200000	27.56250	3.273750	58.49167	0.9508333	58.85833	3.781667	56.45833
2	1896	64.26667	3.846667	25.40833	3.242917	59.98333	1.0158333	62.07500	3.210000	57.46667
3	1897	64.19167	4.030000	26.47083	3.544583	58.62500	0.9750000	61.30000	3.743333	56.45833
4	1898	62.98333	4.070000	25.31250	3.200833	59.01667	0.8833333	60.44167	4.667500	56.70000
5	1899	63.10000	4.032500	24.67083	2.713750	59.16667	0.6300000	59.96667	3.455000	56.55833
6	1900	63.40833	5.487500	26.00417	3.305833	60.06667	0.6750000	61.22500	3.958333	57.49167
7	1901	61.39167	4.757500	26.99167	3.224583	59.94167	0.7683333	60.24167	2.967500	57.24167
8	1902	63.58333	4.195000	26.97917	3.160000	59.65000	0.7208333	59.73333	4.409167	56.16667
9	1903	61.97500	4.285000	27.06667	2.881667	58.99167	0.6808333	58.48333	3.747500	56.20833
10	1904	62.76667	3.383333	27.31250	3.430000	59.65000	0.7475000	59.53333	3.599167	57.41667

- This data is obtained from the original file. This is used more often since it averaged the annual temperature and precipitation for each state.
- library(dplyr) is used to compile the mean and function write.csv is used to write a new file.

DATASET SUMMARY:

```
> summary(avg)
       X             Group.1        tAL             pAL             tAK       
 Min.   :  1.00   Min.   :1895   Min.   :60.67   Min.   :2.950   Min.   :21.82  
 1st Qu.: 32.25   1st Qu.:1926   1st Qu.:62.47   1st Qu.:4.085   1st Qu.:25.24  
 Median : 63.50   Median :1958   Median :63.22   Median :4.651   Median :26.38  
 Mean   : 63.50   Mean   :1958   Mean   :63.21   Mean   :4.619   Mean   :26.37  
 3rd Qu.: 94.75   3rd Qu.:1989   3rd Qu.:63.87   3rd Qu.:4.988   3rd Qu.:27.28  
 Max.   :126.00   Max.   :2020   Max.   :65.71   Max.   :6.467   Max.   :32.17  
      pAK             tAZ             pAZ             tAR             pAR       
 Min.   :2.385   Min.   :57.20   Min.   :0.5033   Min.   :57.99   Min.   :2.733  
 1st Qu.:2.914   1st Qu.:58.78   1st Qu.:0.8752   1st Qu.:59.80   1st Qu.:3.744  
 Median :3.127   Median :59.54   Median :1.0008   Median :60.48   Median :4.080  
 Mean   :3.085   Mean   :59.67   Mean   :1.0228   Mean   :60.55   Mean   :4.175  
 3rd Qu.:3.254   3rd Qu.:60.40   3rd Qu.:1.1590   3rd Qu.:61.24   3rd Qu.:4.603  
 Max.   :3.628   Max.   :63.03   Max.   :1.8975   Max.   :63.61   Max.   :6.017  
      tCA             pCA             tCO             pCO             tCT       
 Min.   :55.38   Min.   :0.6608   Min.   :41.78   Min.   :0.9875   Min.   :44.33  
 1st Qu.:56.78   1st Qu.:1.4737   1st Qu.:43.91   1st Qu.:1.3525   1st Qu.:47.57  
 Median :57.48   Median :1.8262   Median :44.72   Median :1.5196   Median :48.24  
 Mean   :57.64   Mean   :1.8459   Mean   :44.85   Mean   :1.4981   Mean   :48.35  
 3rd Qu.:58.37   3rd Qu.:2.1175   3rd Qu.:45.60   3rd Qu.:1.6196   3rd Qu.:49.02  
 Max.   :61.45   Max.   :3.5383   Max.   :48.32   Max.   :2.1267   Max.   :52.47  
      pCT             tDE             pDE             tFL             pFL       
 Min.   :2.561   Min.   :50.92   Min.   :2.281   Min.   :67.98   Min.   :3.357  
 1st Qu.:3.581   1st Qu.:53.59   1st Qu.:3.277   1st Qu.:69.75   1st Qu.:4.109  
 Median :3.894   Median :54.48   Median :3.599   Median :70.24   Median :4.430  
 Mean   :3.935   Mean   :54.54   Mean   :3.636   Mean   :70.35   Mean   :4.474  
 3rd Qu.:4.296   3rd Qu.:55.19   3rd Qu.:3.892   3rd Qu.:70.96   3rd Qu.:4.820  
 Max.   :5.308   Max.   :58.48   Max.   :5.004   Max.   :73.36   Max.   :6.078  
      tGA             pGA             tID             pID             tIL       
 Min.   :61.40   Min.   :2.588   Min.   :39.67   Min.   :1.347   Min.   :48.33  
 1st Qu.:62.86   1st Qu.:3.750   1st Qu.:41.88   1st Qu.:1.784   1st Qu.:50.79  
 Median :63.51   Median :4.110   Median :42.77   Median :1.960   Median :51.73  
 Mean   :63.54   Mean   :4.171   Mean   :42.80   Mean   :1.980   Mean   :51.79  
 3rd Qu.:64.10   3rd Qu.:4.593   3rd Qu.:43.58   3rd Qu.:2.178   3rd Qu.:52.73  
 Max.   :66.19   Max.   :5.872   Max.   :46.92   Max.   :2.675   Max.   :55.77  
      pIL             tIN             pIN             tIA             pIA       
 Min.   :2.127   Min.   :48.07   Min.   :2.426   Min.   :43.96   Min.   :1.684  
 1st Qu.:2.890   1st Qu.:50.52   1st Qu.:3.093   1st Qu.:46.59   1st Qu.:2.436  
 Median :3.118   Median :51.37   Median :3.372   Median :47.57   Median :2.666  
 Mean   :3.176   Mean   :51.51   Mean   :3.377   Mean   :47.64   Mean   :2.721  
 3rd Qu.:3.457   3rd Qu.:52.40   3rd Qu.:3.663   3rd Qu.:48.58   3rd Qu.:3.016  
 Max.   :4.265   Max.   :55.13   Max.   :4.600   Max.   :52.08   Max.   :3.990  
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      tKS             pKS             tKY             pKY             tLA       
 Min.   :51.61   Min.   :1.278   Min.   :52.58   Min.   :2.417   Min.   :64.33  
 1st Qu.:53.29   1st Qu.:2.016   1st Qu.:54.77   1st Qu.:3.591   1st Qu.:65.90  
 Median :54.05   Median :2.269   Median :55.56   Median :3.986   Median :66.49  
 Mean   :54.30   Mean   :2.280   Mean   :55.66   Mean   :3.980   Mean   :66.53  
 3rd Qu.:55.14   3rd Qu.:2.562   3rd Qu.:56.59   3rd Qu.:4.311   3rd Qu.:67.22  
 Max.   :58.22   Max.   :3.382   Max.   :58.70   Max.   :5.477   Max.   :68.92  
      pLA             tME             pME             tMD             pMD       
 Min.   :3.050   Min.   :36.52   Min.   :2.486   Min.   :50.58   Min.   :1.940  
 1st Qu.:4.211   1st Qu.:39.35   1st Qu.:3.173   1st Qu.:53.15   1st Qu.:3.263  
 Median :4.804   Median :40.38   Median :3.539   Median :53.94   Median :3.535  
 Mean   :4.767   Mean   :40.36   Mean   :3.557   Mean   :54.05   Mean   :3.576  
 3rd Qu.:5.322   3rd Qu.:41.10   3rd Qu.:3.859   3rd Qu.:54.75   3rd Qu.:3.817  
 Max.   :6.623   Max.   :44.63   Max.   :5.133   Max.   :57.49   Max.   :5.385  
      tMA             pMA             tMI             pMI             tMN       
 Min.   :43.28   Min.   :2.447   Min.   :39.02   Min.   :1.890   Min.   :35.67  
 1st Qu.:46.40   1st Qu.:3.450   1st Qu.:42.75   1st Qu.:2.471   1st Qu.:39.05  
 Median :47.13   Median :3.730   Median :43.74   Median :2.640   Median :40.15  
 Mean   :47.23   Mean   :3.784   Mean   :43.82   Mean   :2.639   Mean   :40.32  
 3rd Qu.:47.94   3rd Qu.:4.129   3rd Qu.:44.60   3rd Qu.:2.806   3rd Qu.:41.35  
 Max.   :51.33   Max.   :5.086   Max.   :48.42   Max.   :3.486   Max.   :45.27  
      pMN             tMS             pMS             tMO             pMO       
 Min.   :1.257   Min.   :61.41   Min.   :3.286   Min.   :51.83   Min.   :2.093  
 1st Qu.:2.004   1st Qu.:63.09   1st Qu.:4.147   1st Qu.:53.65   1st Qu.:3.132  
 Median :2.230   Median :63.69   Median :4.584   Median :54.61   Median :3.382  
 Mean   :2.203   Mean   :63.75   Mean   :4.662   Mean   :54.64   Mean   :3.432  
 3rd Qu.:2.421   3rd Qu.:64.42   3rd Qu.:5.105   3rd Qu.:55.35   3rd Qu.:3.694  
 Max.   :2.972   Max.   :66.42   Max.   :6.739   Max.   :58.55   Max.   :4.762  
      tMT             pMT             tNE             pNE             tNV       
 Min.   :37.16   Min.   :1.052   Min.   :45.50   Min.   :1.113   Min.   :47.25  
 1st Qu.:40.00   1st Qu.:1.426   1st Qu.:47.61   1st Qu.:1.693   1st Qu.:48.75  
 Median :41.33   Median :1.570   Median :48.36   Median :1.882   Median :49.67  
 Mean   :41.31   Mean   :1.563   Mean   :48.55   Mean   :1.905   Mean   :49.74  
 3rd Qu.:42.46   3rd Qu.:1.706   3rd Qu.:49.75   3rd Qu.:2.123   3rd Qu.:50.48  
 Max.   :44.90   Max.   :2.179   Max.   :52.72   Max.   :2.958   Max.   :53.03  
      pNV             tNH             pNH             tNJ             pNJ       
 Min.   :0.5200   Min.   :38.77   Min.   :2.721   Min.   :47.83   Min.   :2.439  
 1st Qu.:0.7377   1st Qu.:41.65   1st Qu.:3.351   1st Qu.:50.91   1st Qu.:3.404  
 Median :0.8183   Median :42.62   Median :3.636   Median :51.59   Median :3.758  
 Mean   :0.8510   Mean   :42.63   Mean   :3.694   Mean   :51.80   Mean   :3.791  
 3rd Qu.:0.9644   3rd Qu.:43.32   3rd Qu.:4.004   3rd Qu.:52.59   3rd Qu.:4.080  
 Max.   :1.4833   Max.   :46.59   Max.   :5.091   Max.   :55.87   Max.   :5.397  
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      pNC             tND             pND             tOH             pOH       
 Min.   :2.896   Min.   :34.90   Min.   :0.7342   Min.   :46.84   Min.   :2.232  
 1st Qu.:3.830   1st Qu.:38.43   1st Qu.:1.3050   1st Qu.:49.74   1st Qu.:3.031  
 Median :4.096   Median :39.77   Median :1.4708   Median :50.55   Median :3.215  
 Mean   :4.128   Mean   :39.82   Mean   :1.4630   Mean   :50.66   Mean   :3.243  
 3rd Qu.:4.407   3rd Qu.:41.07   3rd Qu.:1.6279   3rd Qu.:51.60   3rd Qu.:3.425  
 Max.   :5.696   Max.   :45.02   Max.   :2.0325   Max.   :54.09   Max.   :4.662  
      tOK             pOK             tOR             pOR             tPA       
 Min.   :57.38   Min.   :1.693   Min.   :43.69   Min.   :1.847   Min.   :45.18  
 1st Qu.:58.90   1st Qu.:2.459   1st Qu.:45.75   1st Qu.:2.400   1st Qu.:47.58  
 Median :59.68   Median :2.810   Median :46.60   Median :2.617   Median :48.19  
 Mean   :59.79   Mean   :2.834   Mean   :46.66   Mean   :2.674   Mean   :48.37  
 3rd Qu.:60.56   3rd Qu.:3.211   3rd Qu.:47.59   3rd Qu.:2.969   3rd Qu.:49.18  
 Max.   :63.15   Max.   :4.477   Max.   :50.36   Max.   :4.072   Max.   :51.80  
      pPA             tRI             pRI             tSC             pSC       
 Min.   :2.405   Min.   :44.77   Min.   :2.348   Min.   :60.66   Min.   :2.643  
 1st Qu.:3.305   1st Qu.:47.99   1st Qu.:3.474   1st Qu.:61.88   1st Qu.:3.659  
 Median :3.504   Median :48.83   Median :3.763   Median :62.56   Median :3.893  
 Mean   :3.547   Mean   :48.91   Mean   :3.834   Mean   :62.60   Mean   :3.986  
 3rd Qu.:3.774   3rd Qu.:49.77   3rd Qu.:4.115   3rd Qu.:63.29   3rd Qu.:4.311  
 Max.   :5.337   Max.   :52.88   Max.   :5.289   Max.   :65.07   Max.   :5.777  
      tSD             pSD             tTN             pTN             tTX       
 Min.   :40.87   Min.   :0.9083   Min.   :55.35   Min.   :3.037   Min.   :62.33  
 1st Qu.:43.55   1st Qu.:1.4190   1st Qu.:57.04   1st Qu.:3.902   1st Qu.:63.98  
 Median :44.61   Median :1.5771   Median :57.72   Median :4.273   Median :64.82  
 Mean   :44.69   Mean   :1.6122   Mean   :57.84   Mean   :4.356   Mean   :64.83  
 3rd Qu.:45.99   3rd Qu.:1.7852   3rd Qu.:58.72   3rd Qu.:4.794   3rd Qu.:65.51  
 Max.   :49.27   Max.   :2.6158   Max.   :60.65   Max.   :6.239   Max.   :67.77  
      pTX             tUT             pUT             tVT             pVT       
 Min.   :1.172   Min.   :45.08   Min.   :0.6767   Min.   :37.64   Min.   :2.714  
 1st Qu.:1.993   1st Qu.:46.65   1st Qu.:0.9608   1st Qu.:40.72   1st Qu.:3.214  
 Median :2.252   Median :47.76   Median :1.1096   Median :41.56   Median :3.481  
 Mean   :2.272   Mean   :47.77   Mean   :1.1186   Mean   :41.65   Mean   :3.543  
 3rd Qu.:2.554   3rd Qu.:48.67   3rd Qu.:1.2494   3rd Qu.:42.36   3rd Qu.:3.857  
 Max.   :3.436   Max.   :51.32   Max.   :1.6942   Max.   :45.85   Max.   :4.852  
      tVA             pVA             tWA             pWA             tWV       
 Min.   :52.24   Min.   :2.062   Min.   :42.98   Min.   :2.167   Min.   :48.83  
 1st Qu.:54.30   1st Qu.:3.349   1st Qu.:45.43   1st Qu.:3.121   1st Qu.:50.98  
 Median :55.01   Median :3.609   Median :46.27   Median :3.526   Median :51.76  
 Mean   :55.04   Mean   :3.619   Mean   :46.29   Mean   :3.520   Mean   :51.80  
 3rd Qu.:55.79   3rd Qu.:3.826   3rd Qu.:47.08   3rd Qu.:3.934   3rd Qu.:52.66  
 Max.   :57.55   Max.   :5.294   Max.   :49.98   Max.   :4.579   Max.   :54.32  
      pWV             tWI             pWI             tWY             pWY       
 Min.   :2.108   Min.   :37.98   Min.   :1.711   Min.   :37.86   Min.   :0.9133 
 1st Qu.:3.506   1st Qu.:41.58   1st Qu.:2.383   1st Qu.:39.83   1st Qu.:1.1894 
 Median :3.717   Median :42.40   Median :2.642   Median :41.00   Median :1.3433 
 Mean   :3.762   Mean   :42.62   Mean   :2.648   Mean   :40.96   Mean   :1.3234 
 3rd Qu.:4.031   3rd Qu.:43.43   3rd Qu.:2.923   3rd Qu.:41.98   3rd Qu.:1.4454 
 Max.   :5.425   Max.   :47.39   Max.   :3.712   Max.   :44.79   Max.   :1.7083 
```

- Information from summary(avg): 1. can find out max and min 2. median and mean are close (potentially uniformly distributed?)

DESCRIPTIVE STATISTICS:

	X	Group.1	tAL	pAL	tAK	pAK	tAZ	pAZ	tAR	pAR	tCA	pCA	tCO	pCO	tCT	pCT	tDE	pDE	tFL	pFL	tGA	pGA	tID	pID
nbr.val	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126
nbr.null	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nbr.na	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
min	1	1895	60.675	2.95	21.825	2.385	57.2	0.50333	57.9917	2.73333	55.375	0.66083	41.7833	0.9875	44.325	2.56083	50.9167	2.28083	67.9833	3.3575	61.4	2.58833	39.6667	1.3475
max	126	2020	65.7083	6.46714	32.175	3.62833	63.0333	1.8975	63.6083	6.01667	61.45	3.53833	48.3167	2.12667	52.4667	5.3075	58.475	5.00417	73.3583	6.07833	66.1917	5.87167	46.9167	2.675
range	125	125	5.03333	3.51714	10.35	1.24333	5.83333	1.39417	5.61667	3.28333	6.075	2.8775	6.53333	1.13917	8.14167	2.74667	7.55833	2.72333	5.375	2.72083	4.79167	3.28333	7.25	1.3275
sum	8001	246645	7963.99	581.95	3322.13	388.71	7517.85	128.869	7629.04	526.072	7262.84	232.58	5651.02	188.756	6091.54	495.766	6872.58	458.182	8863.59	563.742	8006	525.534	5392.98	249.543
median	63.5	1957.5	63.2208	4.65125	26.3833	3.1275	59.5375	1.00083	60.4833	4.08	57.4833	1.82625	44.7167	1.51958	48.2417	3.89417	54.475	3.59875	70.2417	4.43	63.5083	4.11042	42.775	1.96042
mean	63.5	1957.5	63.2062	4.61865	26.3661	3.085	59.6655	1.02277	60.548	4.17518	57.6416	1.84587	44.8493	1.49807	48.3455	3.93465	54.5443	3.63637	70.3459	4.47414	63.5397	4.17091	42.8015	1.9805
SE.mean	3.2532	3.2532	0.09599	0.05847	0.16881	0.02322	0.10459	0.02137	0.10204	0.06099	0.10299	0.04368	0.11551	0.01886	0.12886	0.05079	0.12681	0.0461	0.09233	0.04669	0.0925	0.05202	0.11507	0.02596
CI.mean.0	6.43849	6.43849	0.18998	0.11571	0.3341	0.04596	0.207	0.04228	0.20194	0.1207	0.20383	0.08645	0.2286	0.03732	0.25503	0.10052	0.25097	0.09124	0.18273	0.09241	0.18308	0.10294	0.22774	0.05137
var	1333.5	1333.5	1.161	0.43069	3.59062	0.06794	1.37833	0.05752	1.31185	0.46866	1.33645	0.24043	1.6811	0.0448	2.09221	0.32505	2.0262	0.26781	1.07413	0.27468	1.0782	0.3409	1.66845	0.08488
std.dev	36.5171	36.5171	1.0775	0.65627	1.89489	0.26065	1.17402	0.23983	1.14536	0.68459	1.15605	0.49034	1.29657	0.21167	1.44645	0.57013	1.42345	0.5175	1.0364	0.5241	1.03837	0.58387	1.29168	0.29135
coef.var	0.57507	0.01865	0.01705	0.14209	0.07187	0.08449	0.01968	0.23449	0.01892	0.16397	0.02006	0.26564	0.02891	0.1413	0.02992	0.1449	0.0261	0.14231	0.01473	0.11714	0.01634	0.13999	0.03018	0.14711

tIL	pIL	tIN	pIN	tIA	pIA	tKS	pKS	tKY	pKY	tLA	pLA	tME	pME	tMD	pMD	tMA	pMA	tMI	pMI	tMN	pMN	tMS	pMS	tMO
126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
48.3333	2.1275	48.0667	2.42583	43.9583	1.68417	51.6083	1.27833	52.5833	2.41667	64.3333	3.05	36.5167	2.48583	50.5833	1.94	43.2833	2.4475	39.025	1.89	35.675	1.25667	61.4083	3.28583	51.825
55.775	4.265	55.1333	4.6	52.075	3.99	58.2167	3.38167	58.7	5.47714	68.9167	6.62333	44.6333	5.1325	57.4917	5.385	51.3333	5.08583	48.425	3.48583	45.2667	2.97167	66.425	6.73857	58.55
7.44167	2.1375	7.06667	2.17417	8.11667	2.30583	6.60833	2.10333	6.11667	3.06048	4.58333	3.57333	8.11667	2.64667	6.90833	3.445	8.05	2.63833	9.4	1.59583	9.59167	1.715	5.01667	3.45274	6.725
6525.71	400.21	6490.36	425.443	6003.14	342.81	6841.18	287.248	7013.6	501.441	8383.12	600.629	5085.1	448.187	6810.56	450.545	5951.61	476.753	5520.95	332.558	5079.92	277.619	8032.65	587.443	6884.72
51.7333	3.11833	51.3667	3.37208	47.5667	2.66625	54.0542	2.26875	55.5625	3.98583	66.4875	4.80375	40.3792	3.53875	53.9375	3.53542	47.1292	3.73	43.7417	2.63958	40.1458	2.23042	63.6875	4.58417	54.6125
51.7914	3.17627	51.5108	3.37653	47.644	2.72071	54.2951	2.27975	55.6635	3.97969	66.5327	4.76689	40.358	3.55704	54.052	3.57575	47.235	3.78375	43.8171	2.63935	40.3168	2.20333	63.7512	4.66224	54.6407
0.127	0.04106	0.12269	0.04008	0.13898	0.03995	0.12273	0.037	0.11092	0.04942	0.09061	0.06419	0.13129	0.04237	0.11688	0.04448	0.12634	0.04704	0.14418	0.02452	0.16397	0.0274	0.0957	0.0636	0.11829
0.25136	0.08127	0.24282	0.07933	0.27507	0.07907	0.2429	0.07323	0.21952	0.09781	0.17933	0.12704	0.25985	0.08386	0.23133	0.08804	0.25005	0.09309	0.28534	0.04853	0.32451	0.05422	0.18939	0.12587	0.23412
2.0324	0.21246	1.89674	0.20245	2.43389	0.20112	1.89796	0.17252	1.55021	0.30774	1.03446	0.51913	2.17197	0.22623	1.72139	0.24932	2.01128	0.27875	2.61914	0.07575	3.38748	0.09457	1.15387	0.50968	1.76313
1.42562	0.46094	1.37722	0.44994	1.56009	0.44846	1.37766	0.41535	1.24507	0.55475	1.01709	0.7205	1.47376	0.47564	1.31202	0.49932	1.4182	0.52797	1.61838	0.27523	1.84051	0.30752	1.07418	0.71392	1.32783
0.02753	0.14512	0.02674	0.13326	0.03274	0.16483	0.02537	0.18219	0.02237	0.13939	0.01529	0.15115	0.03652	0.13372	0.02427	0.13964	0.03002	0.13954	0.03693	0.10428	0.04565	0.13957	0.01685	0.15313	0.0243

- library(pastecs) and stat.desc(avg) are used to calculate descriptive statistics of each variable

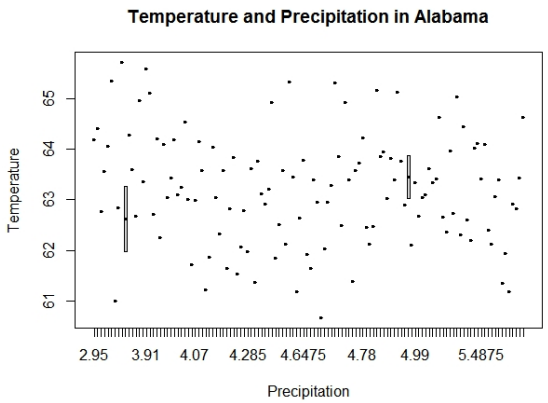
DESCRIPTIVE STATISTICS (CONT.)

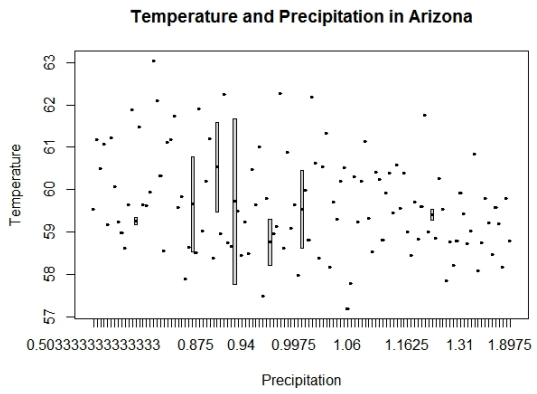
pMO	tMT	pMT	tNE	pNE	tNV	pNV	tNH	pNH	tNJ	pNJ	tNM	pNM	tNY	pNY	tNC	pNC	tND	pND	tOH	pOH	tOK	pOK	tOR	pOR
126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.09333	37.1583	1.05167	45.5	1.11333	47.25	0.52	38.775	2.72083	47.825	2.43917	50.75	0.54833	41.0833	2.63	56.3833	2.89583	34.9	0.73417	46.8417	2.2325	57.3833	1.69333	43.6917	1.8475
4.76167	44.9	2.17917	52.7167	2.95833	53.0333	1.48333	46.5917	5.09083	55.8667	5.39667	56.3833	2.21417	48.8417	4.6425	61.2667	5.69583	45.025	2.0325	54.0917	4.6625	63.15	4.47667	50.3583	4.0725
2.66833	7.74167	1.1275	7.21667	1.845	5.78333	0.96333	7.81667	2.37	8.04167	2.9575	5.63333	1.66583	7.75833	2.0125	4.88333	2.8	10.125	1.29833	7.25	2.43	5.76667	2.78333	6.66667	2.225
432.434	5205.12	196.978	6117.55	240.053	6267.72	107.222	5370.88	465.414	6527.08	477.658	6696.18	145.968	5642.63	429.252	7400.66	520.164	5017.87	184.335	6383.08	408.607	7534.05	357.116	5879.19	336.965
3.38208	41.3333	1.57	48.3625	1.88167	49.6667	0.81833	42.6208	3.63625	51.5917	3.75833	53.0125	1.14333	44.6542	3.3625	58.6708	4.09583	39.7708	1.47083	50.55	3.215	59.6792	2.81	46.6	2.61667
3.43201	41.3105	1.56332	48.552	1.90518	49.7438	0.85097	42.626	3.69376	51.8022	3.79094	53.1443	1.15848	44.7828	3.40676	58.7354	4.12829	39.8243	1.46297	50.6594	3.24291	59.794	2.83426	46.6602	2.67432
0.04836	0.1499	0.0187	0.13209	0.0291	0.11247	0.01625	0.1272	0.04345	0.13535	0.04598	0.1012	0.02161	0.12278	0.03289	0.09682	0.04441	0.17644	0.02159	0.12039	0.03581	0.10606	0.04699	0.11337	0.03846
0.09572	0.29668	0.03701	0.26141	0.0576	0.22258	0.03215	0.25174	0.08599	0.26787	0.091	0.20028	0.04276	0.243	0.06509	0.19161	0.08789	0.34919	0.04274	0.23827	0.07087	0.2099	0.09301	0.22438	0.07612
0.29472	2.83135	0.04407	2.19828	0.10671	1.59371	0.03326	2.03861	0.23785	2.30822	0.26636	1.29033	0.05883	1.89951	0.13629	1.18107	0.24848	3.92245	0.05876	1.82626	0.16156	1.41733	0.27827	1.6195	0.18639
0.54288	1.68266	0.20993	1.48266	0.32667	1.26242	0.18236	1.4278	0.4877	1.51928	0.51611	1.13593	0.24254	1.37823	0.36918	1.08677	0.49848	1.98052	0.2424	1.35139	0.40194	1.19052	0.52751	1.2726	0.43173
0.15818	0.04073	0.13429	0.03054	0.17146	0.02538	0.2143	0.0335	0.13203	0.02933	0.13614	0.02137	0.20936	0.03078	0.10837	0.0185	0.12075	0.04973	0.16569	0.02668	0.12395	0.01991	0.18612	0.02727	0.16143

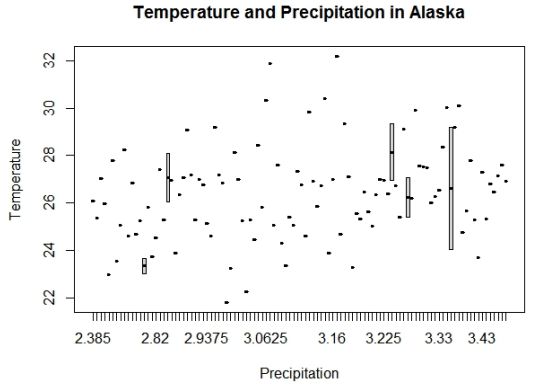
tPA	pPA	tRI	pRI	tSC	pSC	tSD	pSD	tTN	pTN	tTX	pTX	tUT	pUT	tVT	pVT	tVA	pVA	tWA	pWA	tWV	pWV	tWI	pWI	tWY	pWY
126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45.18333	2.405	44.775	2.348333	60.65833	2.643333	40.86667	0.908333	55.35	3.036667	62.325	1.171667	45.075	0.676667	37.64167	2.714167	52.24167	2.061667	42.975	2.166667	48.83333	2.108333	37.975	1.710833	37.85833	0.913333
51.8	5.336667	52.875	5.289167	65.06667	5.776667	49.26667	2.615833	60.65	6.238571	67.76667	3.435833	51.31667	1.694167	45.85	4.851667	57.55	5.294167	49.975	4.579167	54.31667	5.425	47.39167	3.7125	44.79167	1.708333
6.616667	2.931667	8.1	2.940833	4.408333	3.133333	8.4	1.7075	5.3	3.201905	5.441667	2.264167	6.241667	1.0175	8.208333	2.1375	5.308333	3.2325	7	2.4125	5.483333	3.316667	9.416667	2.001667	6.933333	0.795
6095.083	446.9394	6162.954	483.1357	7887.861	502.1933	5631.221	203.135	7288.24	548.8452	8168.714	286.2774	6019.571	140.9449	5247.361	446.4556	6935.374	455.9504	5832.767	443.541	6526.664	473.9902	5370.445	333.5945	5160.431	166.7499
48.19167	3.504167	48.825	3.762917	62.5625	3.893333	44.60833	1.577083	57.71667	4.273333	64.81667	2.251667	47.75833	1.109583	41.5625	3.48125	55.00833	3.609167	46.26667	3.525833	51.7625	3.7175	42.40417	2.641667	41	1.343333
48.37368	3.547138	48.91233	3.83441	62.60207	3.985661	44.69223	1.612183	57.84318	4.355915	64.83107	2.272043	47.77438	1.11861	41.64572	3.543298	55.04265	3.618654	46.2918	3.520166	51.79892	3.761827	42.62258	2.647576	40.9558	1.323412
0.112844	0.038877	0.134571	0.048925	0.094507	0.048616	0.158633	0.025738	0.102631	0.053153	0.096999	0.038534	0.125146	0.018911	0.13072	0.039806	0.101638	0.042775	0.109665	0.046347	0.105747	0.041184	0.148405	0.031931	0.130733	0.016848
0.223333	0.076942	0.266333	0.096828	0.18704	0.096217	0.313954	0.050939	0.203119	0.105197	0.191973	0.076264	0.247679	0.037427	0.258711	0.078781	0.201153	0.084658	0.217041	0.091726	0.209286	0.081509	0.293713	0.063195	0.258738	0.033344
1.604467	0.190439	2.281777	0.301598	1.125369	0.297803	3.170711	0.08347	1.327166	0.355984	1.185508	0.187095	1.973351	0.045059	2.153046	0.199652	1.301604	0.230546	1.515333	0.27065	1.408978	0.213714	2.775048	0.128466	2.153494	0.035766
1.266676	0.436394	1.510555	0.549179	1.060834	0.545713	1.780649	0.288912	1.152027	0.596644	1.08881	0.432544	1.40476	0.212272	1.467326	0.446824	1.140879	0.480152	1.230989	0.52024	1.187004	0.462292	1.665848	0.358421	1.467479	0.189118
0.026185	0.123027	0.030883	0.143224	0.016946	0.136919	0.039842	0.179205	0.019916	0.136973	0.016795	0.190377	0.029404	0.189764	0.035234	0.126104	0.020727	0.132688	0.026592	0.147788	0.022916	0.12289	0.039084	0.135377	0.035831	0.142902

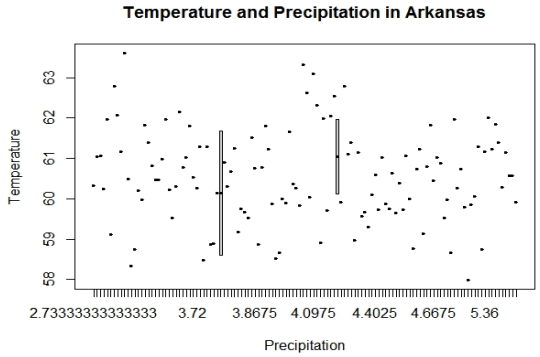
- There is no null and na. The coefficient of variance seems relatively low for all/most of the data points.

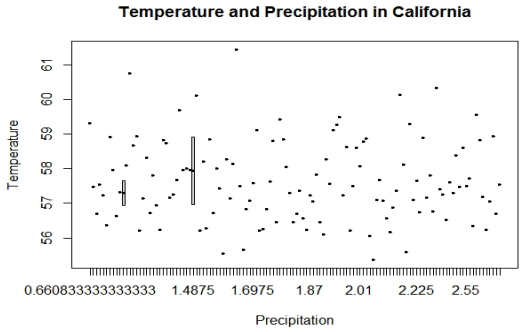
DESCRIPTIVE ANALYSIS: BOX-PLOTS

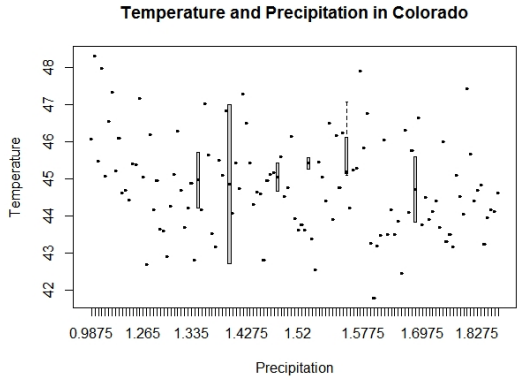


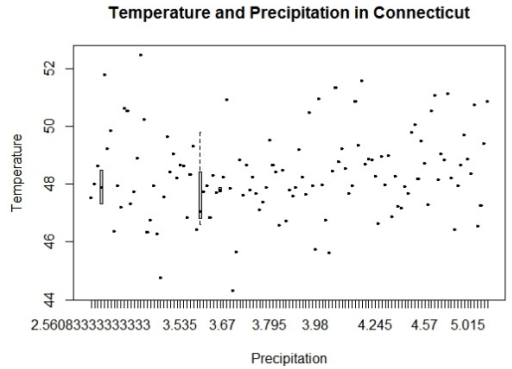


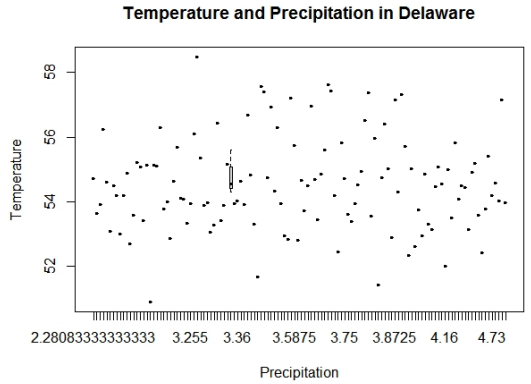


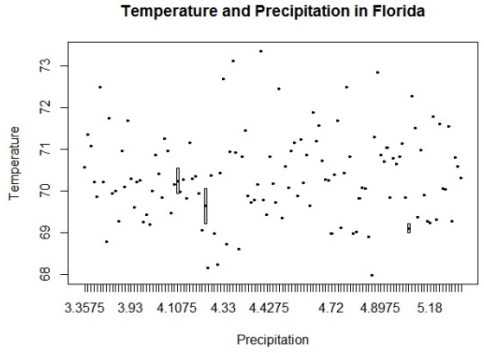




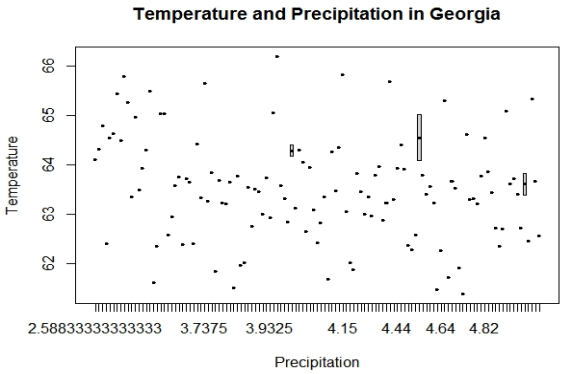


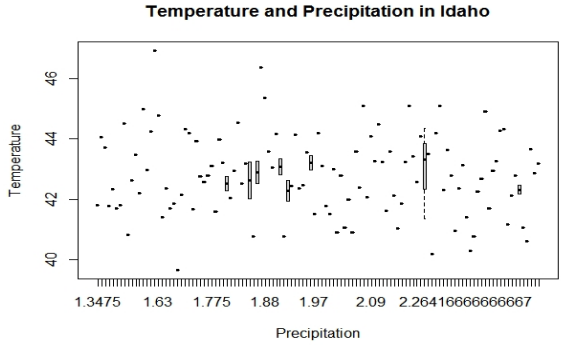


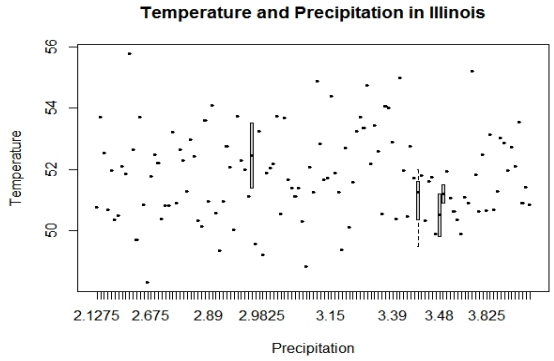


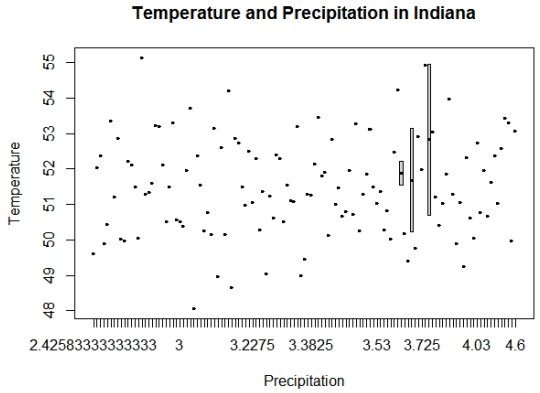


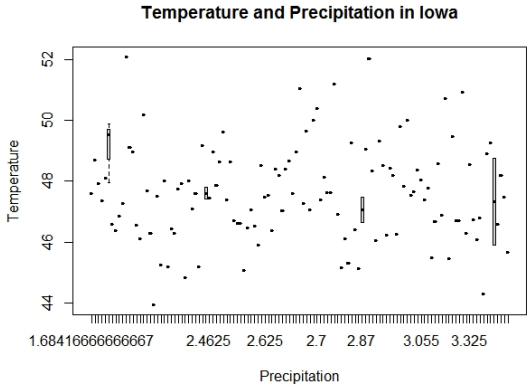
DESCRIPTIVE ANALYSIS: BOX-PLOTS

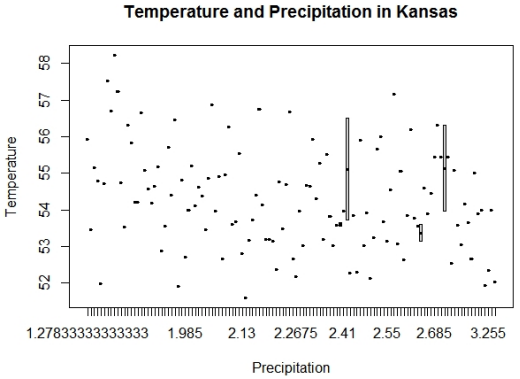


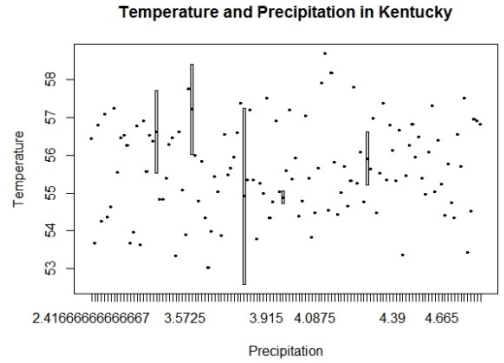


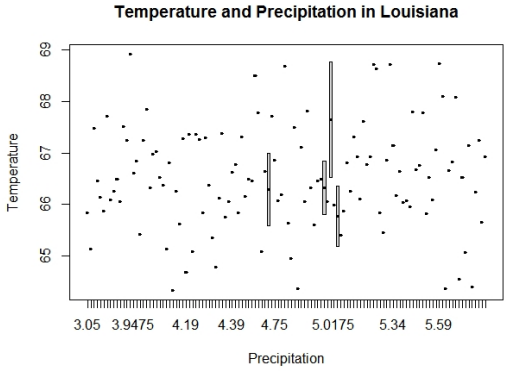


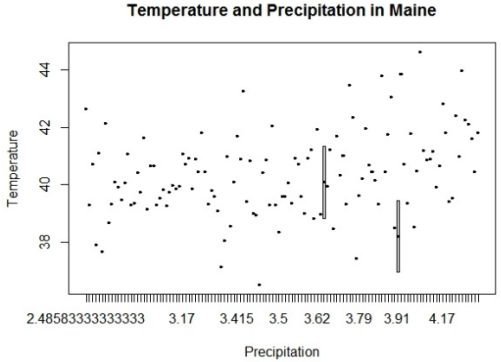




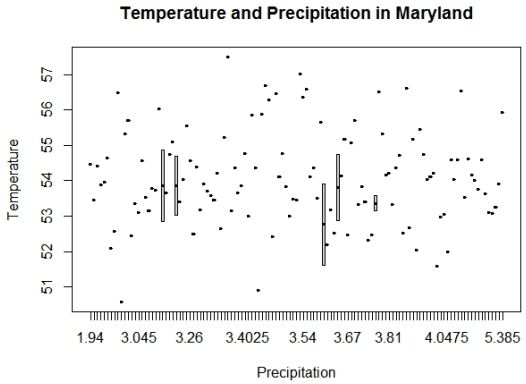


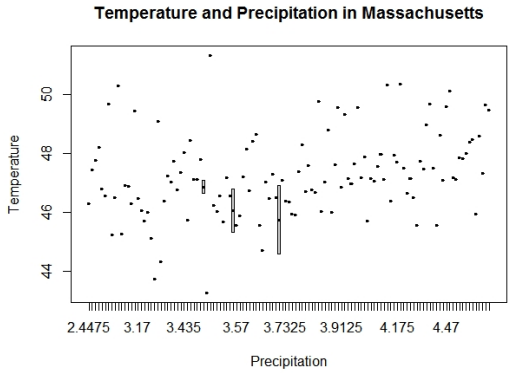


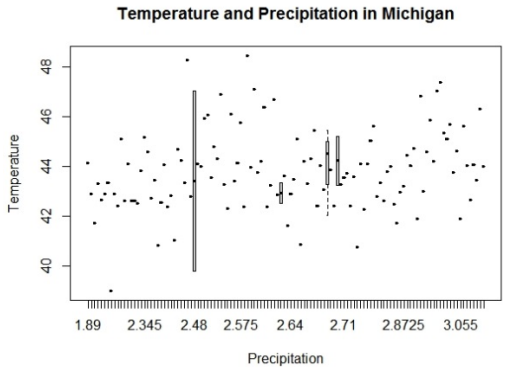


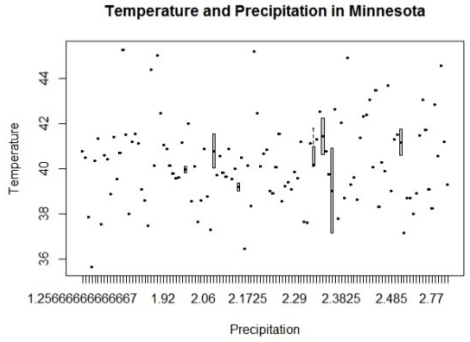


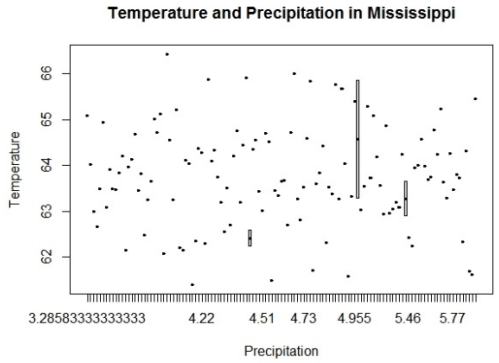
DESCRIPTIVE ANALYSIS: BOX-PLOTS

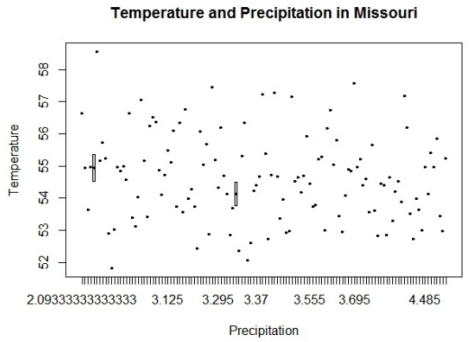


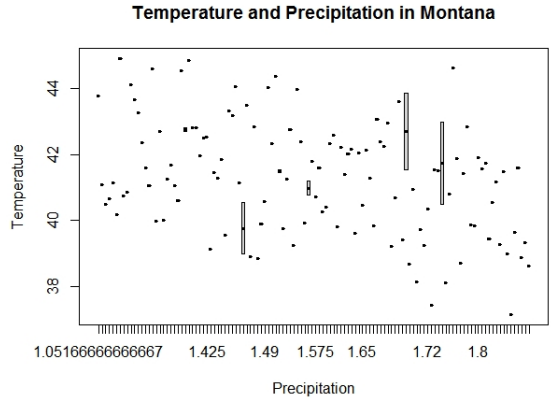


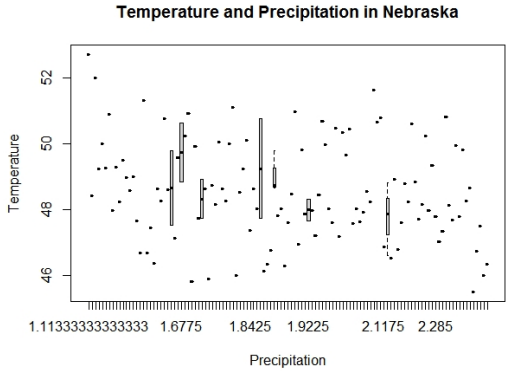


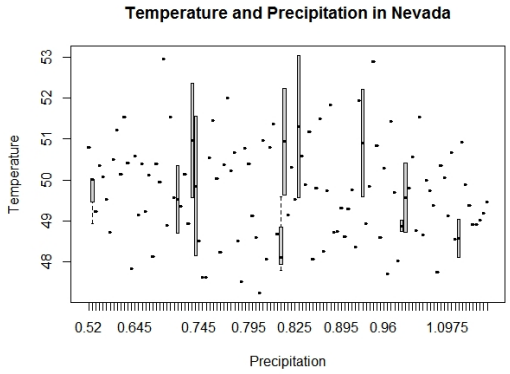




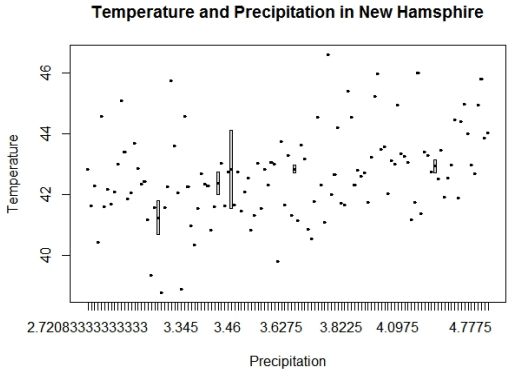


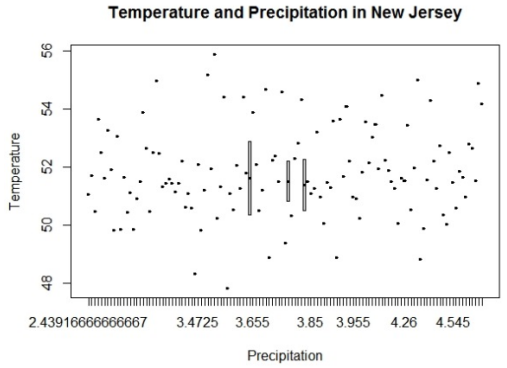


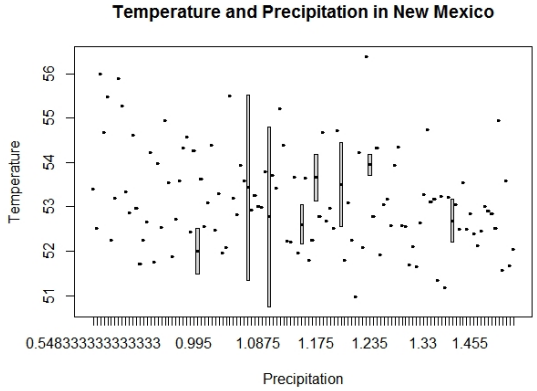


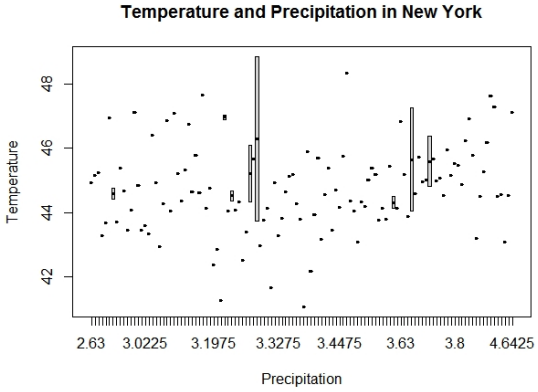


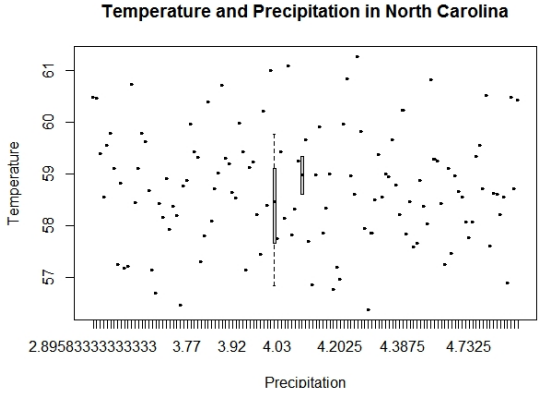
DESCRIPTIVE ANALYSIS: BOX-PLOTS

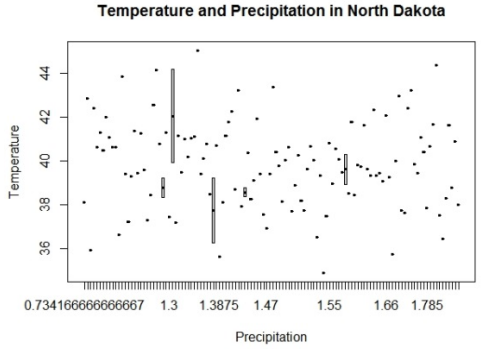


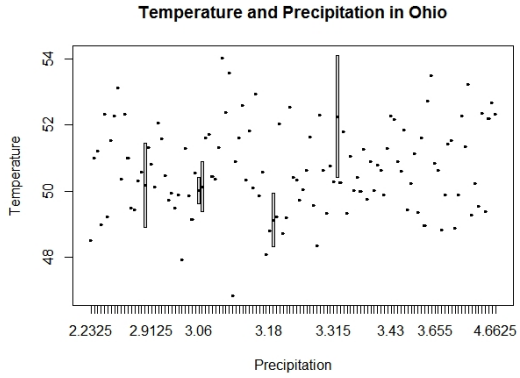


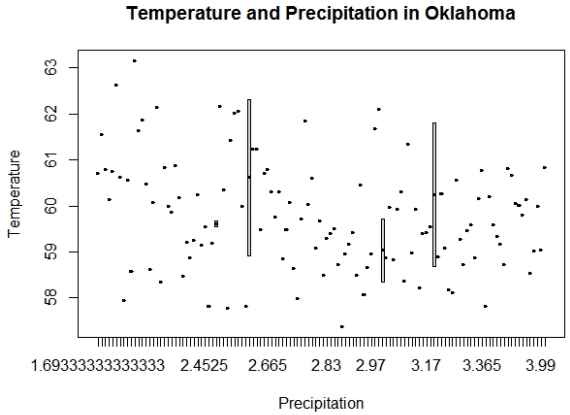


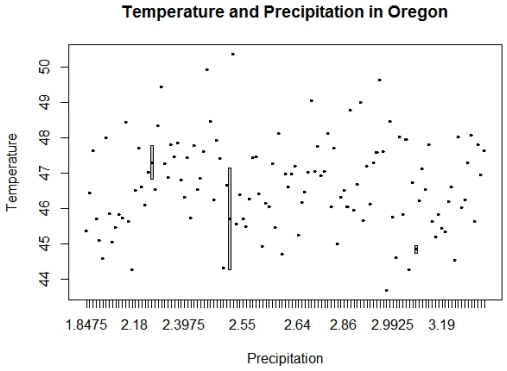




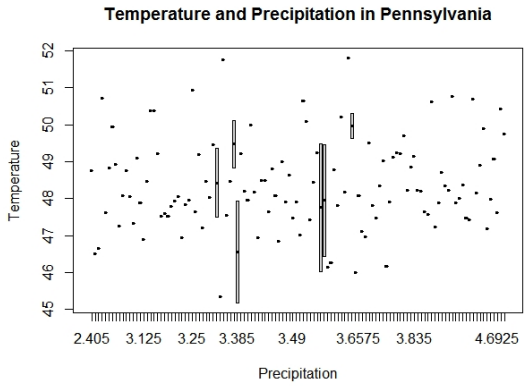


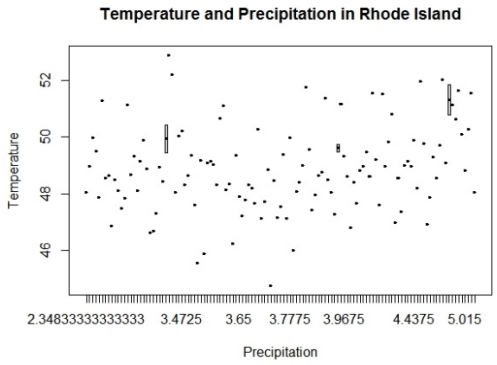


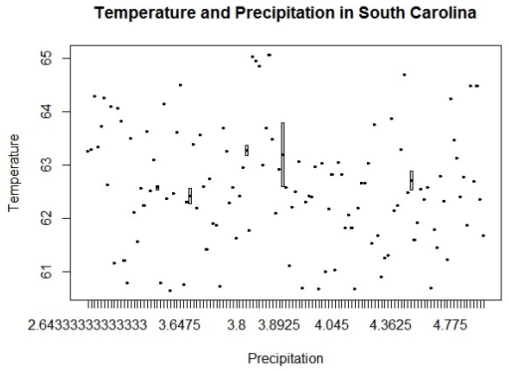


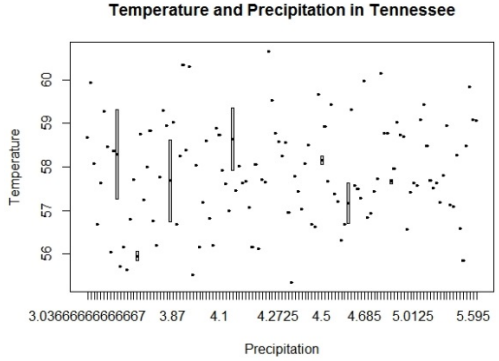


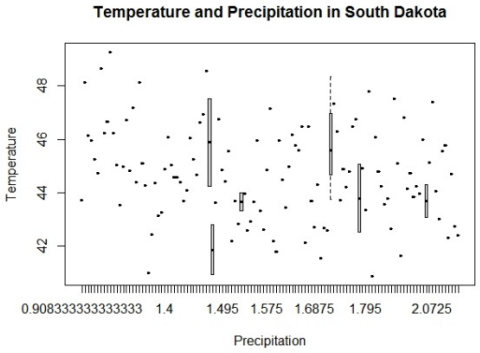
DESCRIPTIVE ANALYSIS: BOX-PLOTS

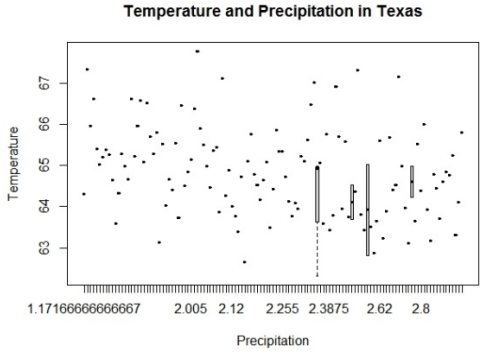


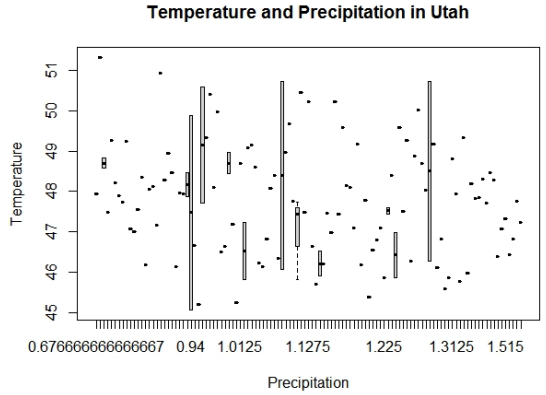


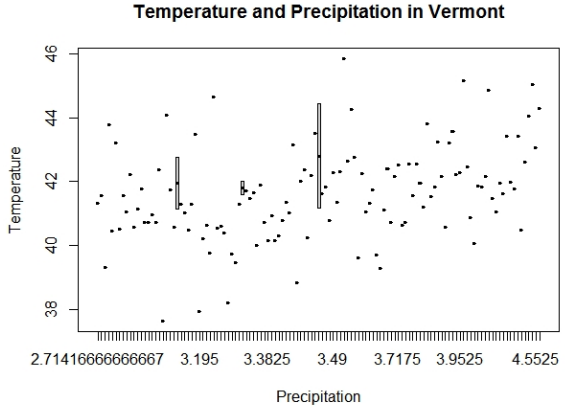


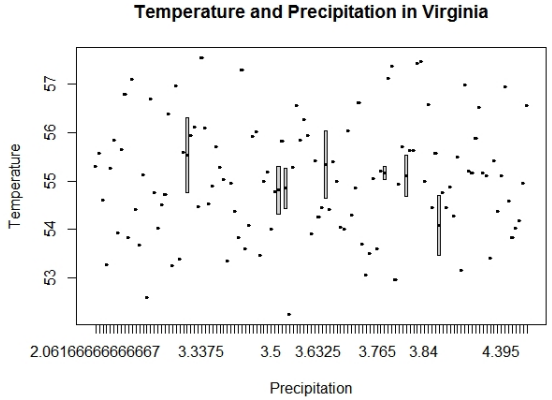




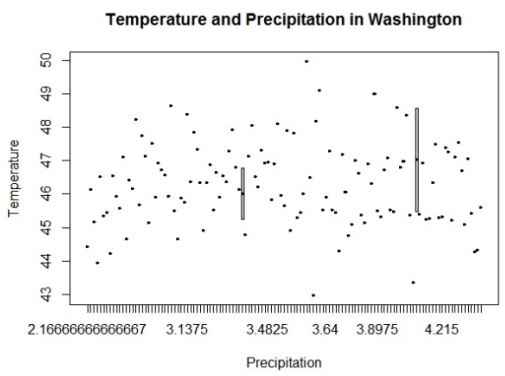


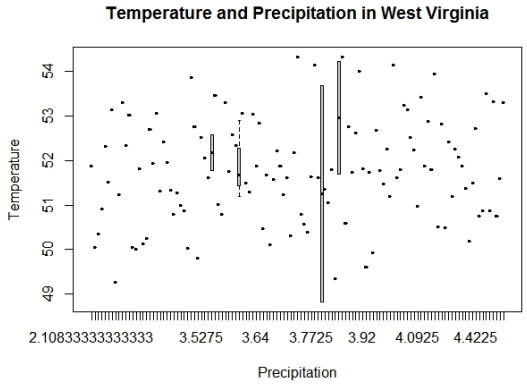


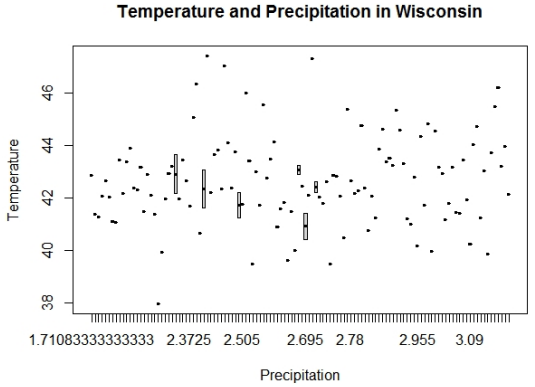


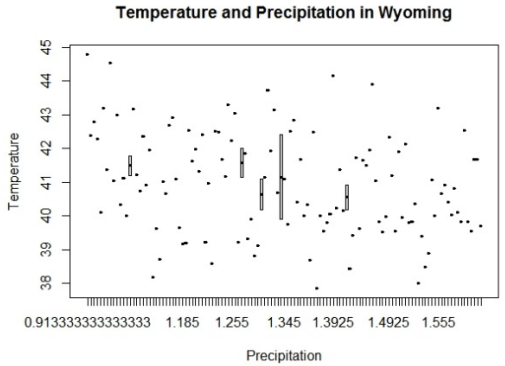


DESCRIPTIVE ANALYSIS: BOX-PLOTS



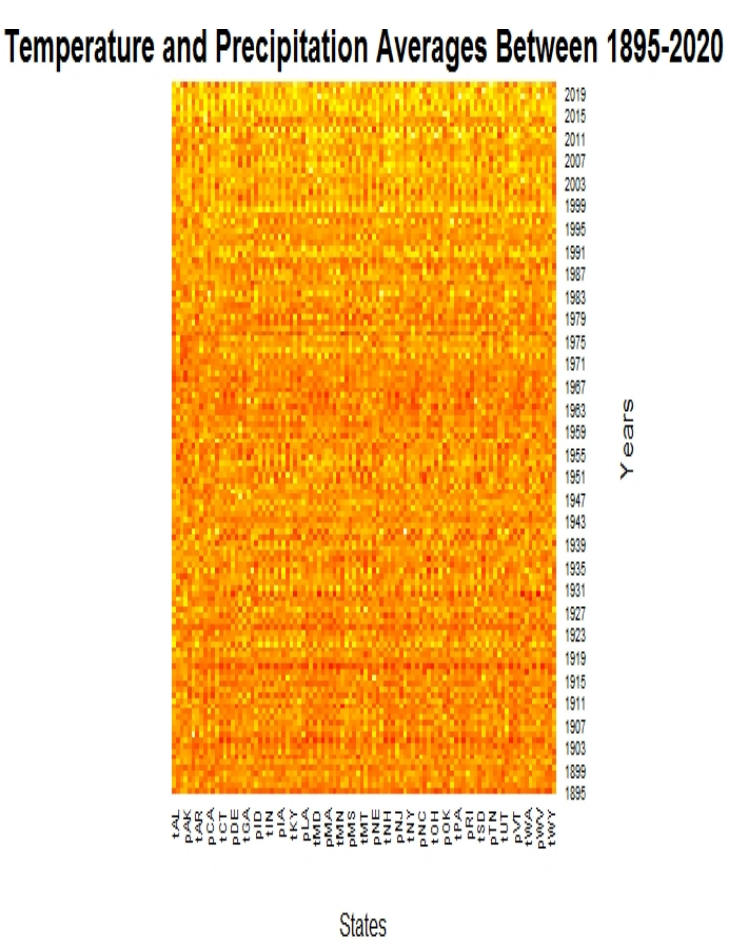


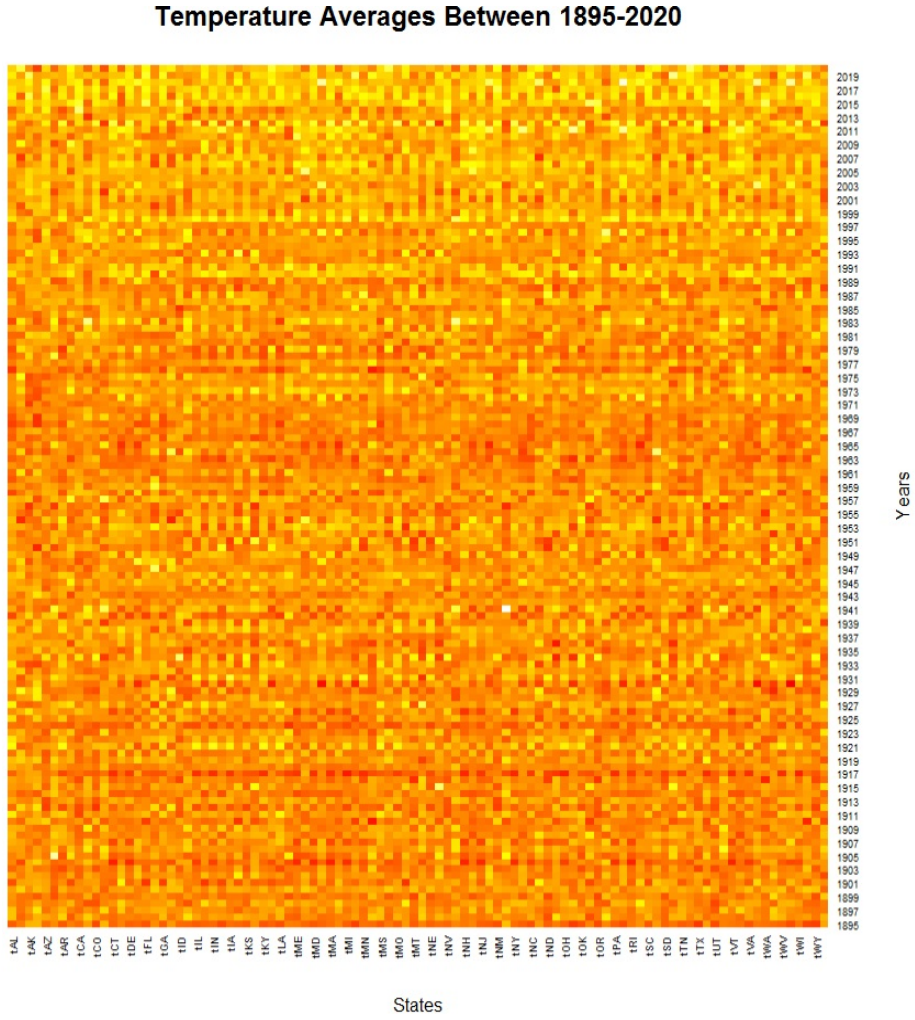




- No "real" correlation between temperature and precipitation that can be generalized to the 49 states
- Values for both variables for each state are generally very spread out.
- Can scan for max and min values from looking at the x and y axis scales.

DESCRIPTIVE ANALYSIS: HEAT MAP





- Temperature and precipitation heat map and temperature heat map seem to share a similar pattern. They indicate that there are periods in which the temperature and/or precipitation are redder/ warmer/wetter compared to the other periods.

Statistical analysis: (Mann- Kendall trend test)

```
> AL <- Kendall(avg$Group.1, avg$tAL)
>       AL
tau = -0.0166, 2-sided pvalue =0.78397
>       AK <- Kendall(avg$Group.1, avg$tAK)
>       AK
tau = 0.195, 2-sided pvalue =0.0012164
>       AZ <- Kendall(avg$Group.1, avg$tAZ)
>       AZ
tau = 0.407, 2-sided pvalue =< 2.22e-16
>       AR <- Kendall(avg$Group.1, avg$tAR)
>       AR
tau = 0.051, 2-sided pvalue =0.39892
>       CA <- Kendall(avg$Group.1, avg$tCA)
>       CA
tau = 0.494, 2-sided pvalue =< 2.22e-16
```

```
> aldf=data.frame(x=avg$Group.1, y=avg$tAL)
> zyp.sen(y~x, aldf)

Call:
NULL

Coefficients:
 Intercept           x
64.3423450  -0.0005814
```

```
sens.slope(avg$pAL, conf.level=0.95)

        Sen's slope

data:  avg$pAL
z = 2.3365, n = 126, p-value = 0.01946
alternative hypothesis: true z is not equal to 0
95 percent confidence interval:
 0.0005952381 0.0067559524
sample estimates:
Sen's slope
    0.00375
```

- library(Kendall) and function Kendall(avg) are used to calculate tau value (to show +/- correlation between temperature vs time or precipitation vs. time), and p-value < 0.05 would reject the null that the two variables are independent of each other.
- There are two methods to calculate Sen's slope (to show how strong two variables correlate to one another): 1. library(zyp) – gives x/slope and intercept. 2. function sens.slope(avg, conf.level=0.95) from library(trend)

STATISTICAL ANALYSIS: (MANN- KENDALL TREND TEST

state	ttau	tpv	tslope	ptau	ppv	pslope
AL	-0.0166	0.78397	-0.00058	0.141	0.019464	0.00375
AK	0.195	1.22E-03	0.01546	-0.0535	0.37577	-0.00048
AZ	0.407	2.22E-16	0.01915	-0.0419	0.48781	-0.00039
AR	0.051	3.99E-01	0.002424	0.151	0.012384	0.003797
CA	0.494	2.22E-16	0.02105	-0.0243	0.68866	-0.00048
CO	0.414	2.22E-16	0.02152	0.0146	0.81002	0.000121
CT	0.478	2.22E-16	0.02449	0.071	0.23931	0.001667
DE	0.435	2.22E-16	0.02368	0.0874	0.14741	0.001688
FL	0.355	2.22E-16	0.01494	0.0234	0.69957	5.00E-04
GA	0.109	0.071711	0.004695	0.0188	0.75657	0.000433
ID	0.318	1.19E-07	0.01592	0.0441	0.4656	0.000514
IL	0.198	0.001056	0.01173	0.205	0.000655	0.003937
IN	0.177	0.003398	0.01012	0.244	5.20E-05	0.0045
IA	0.15	0.012606	0.009375	0.192	0.001409	0.003535
KS	0.222	0.000231	0.01294	0.157	0.009262	0.00259
KY	0.0864	0.15217	0.004938	0.159	0.008337	0.003734
LA	0.0951	0.11566	0.004167	0.169	0.005103	0.005402
ME	0.434	2.22E-16	0.02333	0.187	0.001868	0.003624
MD	0.372	2.22E-16	0.01975	0.0953	0.11422	0.001741
MA	0.459	2.22E-16	0.0231	0.196	0.001122	0.004074
MI	0.35	2.22E-16	0.02114	0.303	4.77E-07	0.003333
MN	0.303	4.77E-07	0.02186	0.208	0.000556	0.002566
MS	0.014	0.8182	6.13E-04	0.184	0.002246	0.005685
MO	0.122	0.043576	0.006915	0.107	0.075107	0.002047
MT	0.298	7.15E-07	0.02127	-0.00445	0.94284	-3.44E-05
NE	0.236	8.92E-05	0.01465	0.141	0.019351	0.001859
NV	0.392	2.22E-16	0.01939	0.0028	0.96468	1.94E-05
NH	0.425	2.22E-16	0.02197	0.246	4.33E-05	0.004846
NJ	0.504	2.22E-16	0.02765	0.0861	0.15339	1.79E-03
NM	0.373	2.22E-16	0.01746	-0.0306	0.61278	-0.00028
NY	0.306	3.58E-07	0.01599	0.217	0.000316	3.36E-03
NC	0.197	0.001064	0.009591	0.0456	0.45028	0.000861
ND	0.298	7.15E-07	0.02383	0.103	0.089189	1.01E-03
OH	0.204	0.000707	0.01122	0.153	0.01105	0.002198
OK	0.104	0.085667	0.004968	0.166	0.00581	3.78E-03
OR	0.461	2.22E-16	0.02206	0.0117	0.84782	0.00017
PA	0.258	1.82E-05	0.01364	0.123	0.041219	1.88E-03
RI	0.531	2.22E-16	0.02799	0.14	0.019795	0.002869
SC	0.159	0.008284	0.007353	0.0302	0.61723	6.88E-04
SD	0.243	5.48E-05	0.01955	0.14	0.02013	0.001667
TN	0.0608	0.31445	0.003241	0.181	0.002693	4.63E-03
TX	0.245	4.70E-05	0.01127	0.114	0.058264	0.001989
UT	0.424	2.22E-16	0.02428	0.00953	0.87599	9.06E-05
VT	0.377	2.22E-16	0.02092	0.312	2.38E-07	0.005296
VA	0.234	0.000103	0.01197	0.0932	0.12216	1.52E-03
WA	0.325	1.19E-07	0.01517	0.0465	0.44147	0.001038
WV	0.147	0.015036	0.007328	0.0532	0.37806	9.34E-04
WI	0.229	0.000142	0.01515	0.205	0.000655	0.003056
WY	0.376	2.22E-16	0.0222	0.0434	0.47208	3.56E-04

- Ttau= tau of temperature; tpv = p value of temperature; tslope= sen's slope of temperature
- Ptau = tau of precipitation; ppv = p value of precipitation; pslope = sen's slope of precipitation

STATES WITH "STATICALLY SIGNIFICANT" TEMPERATURE CHANGE:

```
> temp <- group_by(tandp, state, ttau, tpv, tslope)
> temp1 <- filter(temp, tpv<0.05)
> temp1
# A tibble: 41 x 7
# Groups:   state, ttau, tpv, tslope [41]
   state  ttau      tpv tslope    ptau       ppv    pslope
   <chr> <dbl>    <dbl>  <dbl>   <dbl>     <dbl>     <dbl>
 1 AK    0.195 1.22e- 3 0.0155 -0.0535 0.376      -0.000485
 2 AZ    0.407 2.22e-16 0.0192 -0.0419 0.488      -0.000390
 3 CA    0.494 2.22e-16 0.0210 -0.0243 0.689      -0.000482
 4 CO    0.414 2.22e-16 0.0215  0.0146 0.810       0.000121
```

- There are 41 states with statistically significant temperature increase as seen with positive tau values and positive slopes
- library(dplyr) is used to group and filter values

States with "statically significant" temperature change:

	state	ttau	tpv	tslope	ptau	ppv	pslope
1	AK	0.195	1.2164e-03	0.015460	-0.05350	3.7577e-01	-4.848485e-04
2	AZ	0.407	2.2200e-16	0.019150	-0.04190	4.8781e-01	-3.900709e-04
3	CA	0.494	2.2200e-16	0.021050	-0.02430	6.8866e-01	-4.824561e-04
4	CO	0.414	2.2200e-16	0.021520	0.01460	8.1002e-01	1.207729e-04
5	CT	0.478	2.2200e-16	0.024490	0.07100	2.3931e-01	1.666667e-03
6	DE	0.435	2.2200e-16	0.023680	0.08740	1.4741e-01	1.688034e-03
7	FL	0.355	2.2200e-16	0.014940	0.02340	6.9957e-01	5.000000e-04
8	ID	0.318	1.1921e-07	0.015920	0.04410	4.6560e-01	5.144033e-04
9	IL	0.198	1.0564e-03	0.011730	0.20500	6.5482e-04	3.936782e-03
10	IN	0.177	3.3982e-03	0.010120	0.24400	5.1975e-05	4.500000e-03
11	IA	0.150	1.2606e-02	0.009375	0.19200	1.4094e-03	3.535354e-03
12	KS	0.222	2.3139e-04	0.012940	0.15700	9.2615e-03	2.589606e-03
13	ME	0.434	2.2200e-16	0.023330	0.18700	1.8680e-03	3.623512e-03
14	MD	0.372	2.2200e-16	0.019750	0.09530	1.1422e-01	1.740741e-03
15	MA	0.459	2.2200e-16	0.023100	0.19600	1.1218e-03	4.074074e-03
16	MI	0.350	2.2200e-16	0.021140	0.30300	4.7684e-07	3.333333e-03
17	MN	0.303	4.7684e-07	0.021860	0.20800	5.5623e-04	2.565789e-03
18	MO	0.122	4.3576e-02	0.006915	0.10700	7.5107e-02	2.046569e-03
19	MT	0.298	7.1526e-07	0.021270	-0.00445	9.4284e-01	-3.436426e-05
20	NE	0.236	8.9169e-05	0.014650	0.14100	1.9351e-02	1.858974e-03
21	NV	0.392	2.2200e-16	0.019390	0.00280	9.6468e-01	1.937984e-05
22	NH	0.425	2.2200e-16	0.021970	0.24600	4.3273e-05	4.845679e-03
23	NJ	0.504	2.2200e-16	0.027650	0.08610	1.5339e-01	1.787281e-03
24	NM	0.373	2.2200e-16	0.017460	-0.03060	6.1278e-01	-2.777778e-04
25	NY	0.306	3.5763e-07	0.015990	0.21700	3.1602e-04	3.364198e-03
26	NC	0.197	1.0643e-03	0.009591	0.04560	4.5028e-01	8.608815e-04
27	ND	0.298	7.1526e-07	0.023830	0.10300	8.9189e-02	1.006944e-03
28	OH	0.204	7.0727e-04	0.011220	0.15300	1.1050e-02	2.198276e-03
29	OR	0.461	2.2200e-16	0.022060	0.01170	8.4782e-01	1.700680e-04
30	PA	0.258	1.8239e-05	0.013640	0.12300	4.1219e-02	1.881720e-03
31	RI	0.531	2.2200e-16	0.027990	0.14000	1.9795e-02	2.868732e-03
32	SC	0.159	8.2841e-03	0.007353	0.03020	6.1723e-01	6.884058e-04
33	SD	0.243	5.4836e-05	0.019550	0.14000	2.0130e-02	1.666667e-03
34	TX	0.245	4.6968e-05	0.011270	0.11400	5.8264e-02	1.988994e-03
35	UT	0.424	2.2200e-16	0.024280	0.00953	8.7599e-01	9.057971e-05
36	VT	0.377	2.2200e-16	0.020920	0.31200	2.3842e-07	5.295699e-03
37	VA	0.234	1.0347e-04	0.011970	0.09320	1.2216e-01	1.515873e-03
38	WA	0.325	1.1921e-07	0.015170	0.04650	4.4147e-01	1.038462e-03
39	WV	0.147	1.5036e-02	0.007328	0.05320	3.7806e-01	9.343434e-04
40	WI	0.229	1.4222e-04	0.015150	0.20500	6.5482e-04	3.055560e-03
41	WY	0.376	2.2200e-16	0.022200	0.04340	4.7208e-01	3.559028e-04

Showing 1 to 24 of 41 entries, 7 total columns

States with "statically significant" precipitation change:

	state	ptau	ppv	pslope
1	AL	0.141	1.9464e-02	0.003750000
2	AR	0.151	1.2384e-02	0.003797348
3	IL	0.205	6.5482e-04	0.003936782
4	IN	0.244	5.1975e-05	0.004500000
5	IA	0.192	1.4094e-03	0.003535354
6	KS	0.157	9.2615e-03	0.002589606
7	KY	0.159	8.3371e-03	0.003733766
8	LA	0.169	5.1028e-03	0.005401961
9	ME	0.187	1.8680e-03	0.003623512
10	MA	0.196	1.1218e-03	0.004074074
11	MI	0.303	4.7684e-07	0.003333333
12	MN	0.208	5.5623e-04	0.002565789
13	MS	0.184	2.2459e-03	0.005685358
14	NE	0.141	1.9351e-02	0.001858974
15	NH	0.246	4.3273e-05	0.004845679
16	NY	0.217	3.1602e-04	0.003364198
17	OH	0.153	1.1050e-02	0.002198276
18	OK	0.166	5.8104e-03	0.003782895
19	PA	0.123	4.1219e-02	0.001881720
20	RI	0.140	1.9795e-02	0.002868732
21	SD	0.140	2.0130e-02	0.001666667
22	TN	0.181	2.6925e-03	0.004631783
23	VT	0.312	2.3842e-07	0.005295699
24	WI	0.205	6.5482e-04	0.003055560

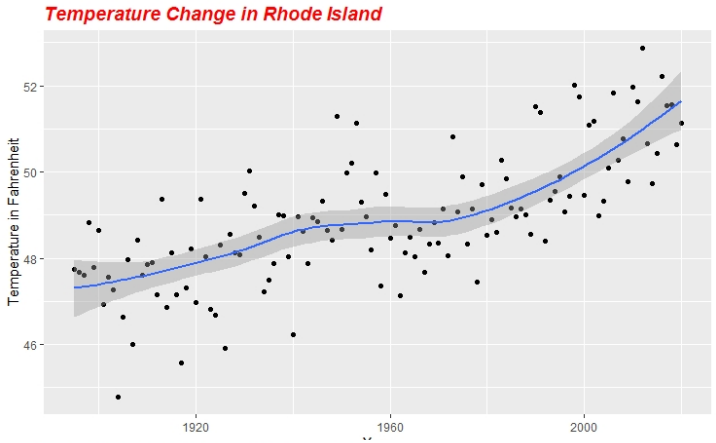
```
> view(temp1)
> precip <- select(tandp, state, ptau, ppv, pslope)
> precip1 <- filter(precip, ppv<0.05)
> precip1
# A tibble: 24 x 4
   state  ptau       ppv  pslope
   <chr> <dbl>     <dbl>   <dbl>
 1 AL    0.141 0.0195    0.00375
 2 AR    0.151 0.0124    0.00380
 3 IL    0.205 0.000655  0.00394
 4 IN    0.244 0.0000520 0.0045
 5 IA    0.192 0.00141   0.00354
 6 KS    0.157 0.00926   0.00259
 7 KY    0.159 0.00834   0.00373
 8 LA    0.169 0.00510   0.00540
 9 ME    0.187 0.00187   0.00362
10 MA    0.196 0.00112   0.00407
# ... with 14 more rows
```

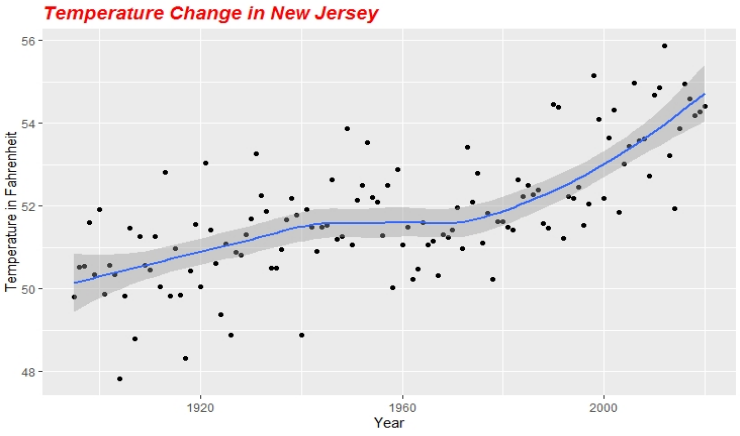
- There are 24 states with statistically significant precipitation change.
- Since ptau and pslope are positive, the precipitation change is increasing.

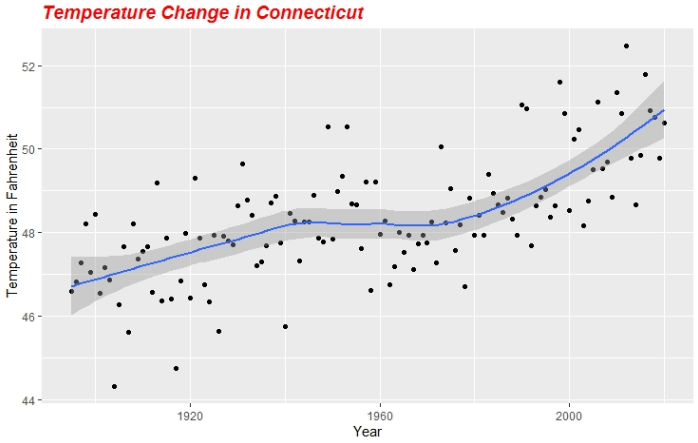
TOP 3 STATES WITH TEMPERATURE INCREASE:

```
> sort(temp$tslope, decreasing=TRUE) [1:3]
[1] 0.02799 0.02765 0.02449

> temp2 <- filter(temp, tslope>=0.02449)
> temp2
# A tibble: 3 x 4
  state  ttau      tpv tslope
  <chr> <dbl>    <dbl>  <dbl>
1 CT    0.478 2.22e-16 0.0245
2 NJ    0.504 2.22e-16 0.0276
3 RI    0.531 2.22e-16 0.0280
```

- library(ggplot2) is used to plot the three top temperature increase.
- Ex: t2 <- ggplot(avg, aes(x=Group.1, y=tNJ)) + xlab("Year") + ylab("Temperature") + ggtitle("Temperature Change in New Jersey") + geom_point() + geom_smooth()
- Ex: t2 + theme(plot.title=element_text(color ="red", size=14, face="bold.italic"))

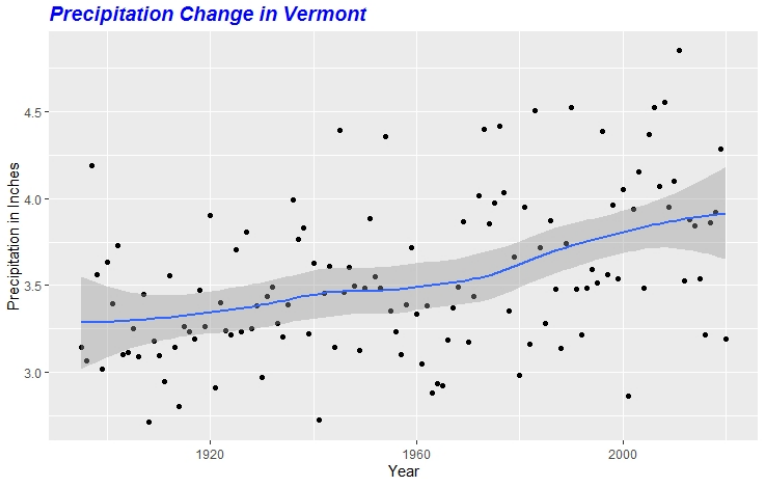


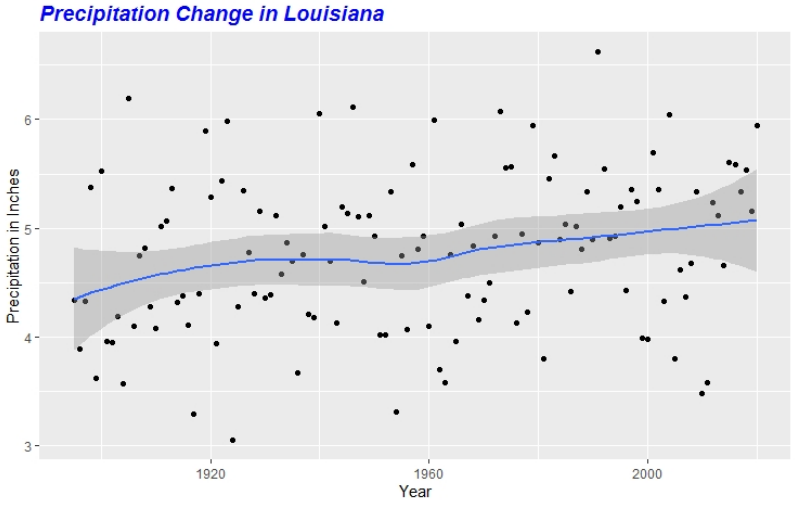


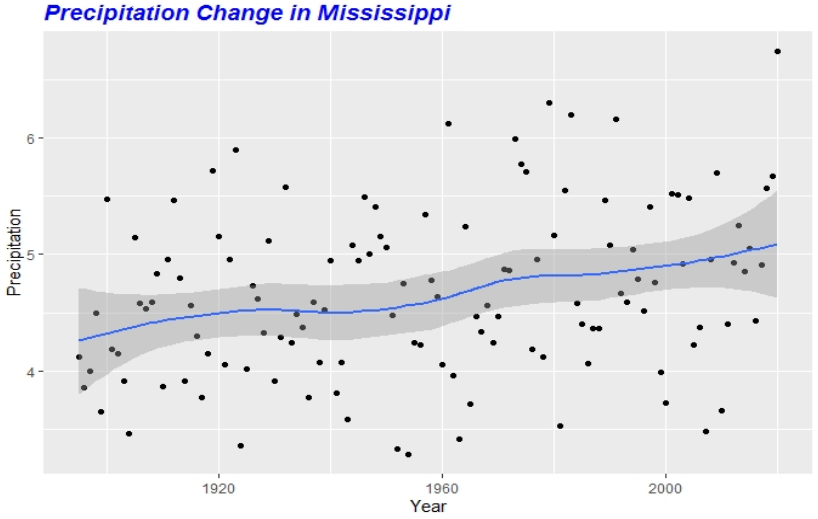


TOP 3 STATES WITH PRECIPITATION INCREASE:

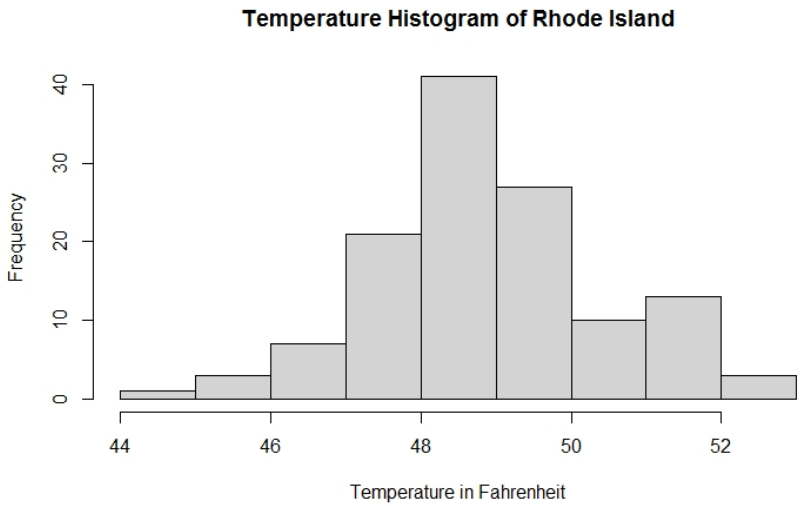
```
> sort(precip$pslope, decreasing=TRUE) [1:3]
[1] 0.005685358 0.005401961 0.005295699

> precip2 <- filter(precip, pslope>=0.005295699)
> precip2
# A tibble: 3 x 4
  state  ptau          ppv  pslope
  <chr> <db1>        <db1>   <db1>
1 LA     0.169 0.00510      0.00540
2 MS     0.184 0.00225      0.00569
3 VT     0.312 0.000000238  0.00530
> precip3 <- arrange(precip2, pslope)
> precip3
# A tibble: 3 x 4
  state  ptau          ppv  pslope
  <chr> <db1>        <db1>   <db1>
1 VT     0.312 0.000000238  0.00530
2 LA     0.169 0.00510      0.00540
3 MS     0.184 0.00225      0.00569
```

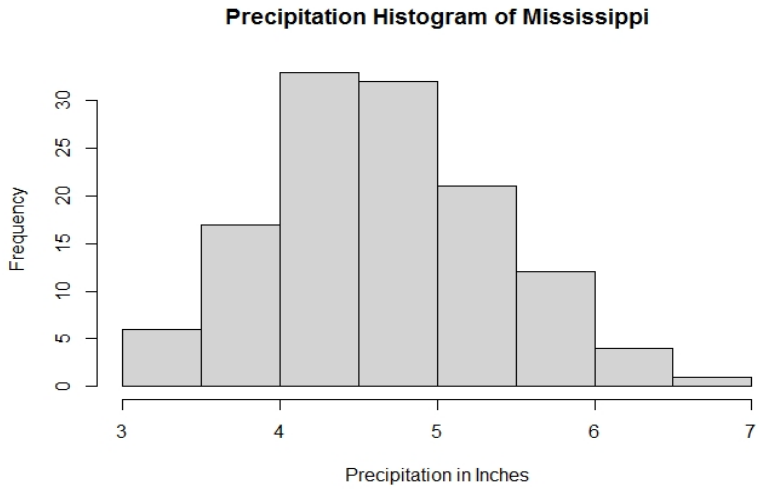






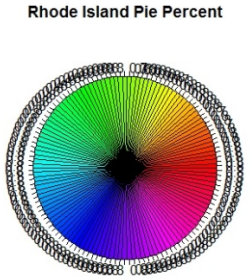
Additional visualization of the top temperature and top precipitation increase: (histogram)



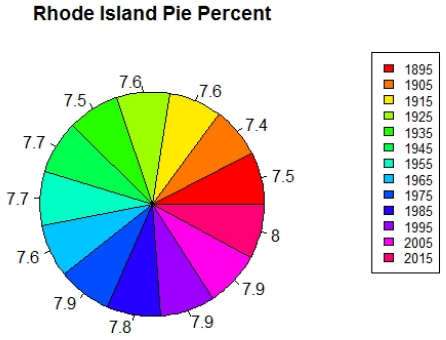


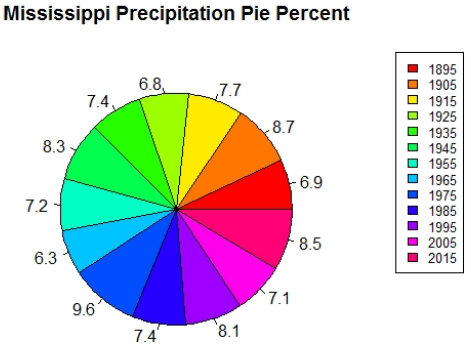
- hist() function is used
- As predicted earlier, temperature and precipitation has mean and median close to each other, which "implies" the shape is somewhat uniformly distributed (the precipitation graph is skewed).

Additional visualization of the top temperature and top precipitation increase: (pie-chart)

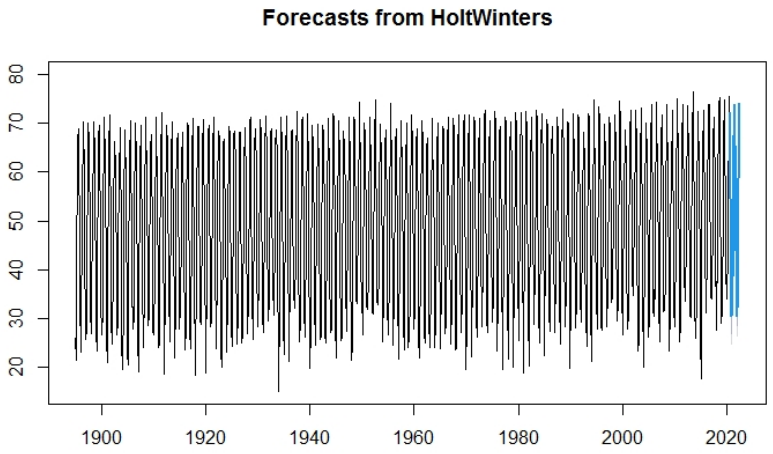


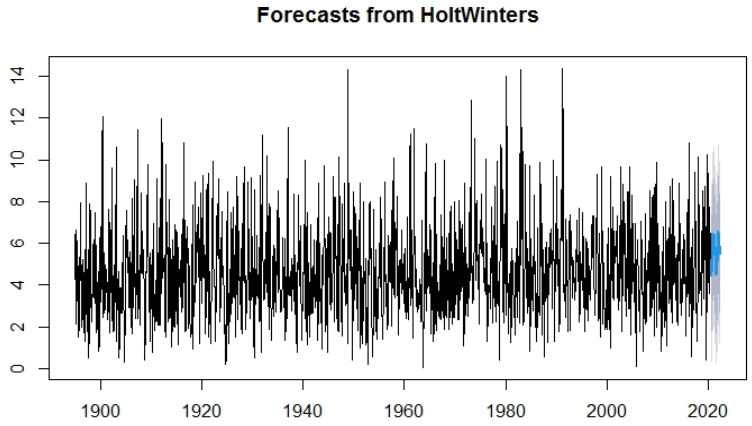
- Pie chart has limitation in terms of portraying the changes (instead of doing annual change, the change has to be calculated every 10 years as seen below in order to show “readable” data.





Predictive model: forecast and HoltWinters for top temperature and precipitation





- library(forecast), function ts(), and holtwinters() are used to predict the trend of the temperature and precipitation change.
- The graph is plotted with the original data from NOAA without averaging the values, and the forecast seems consistent with the prediction that the temperature (Rhode Island) –top picture and precipitation (Mississippi) – bottom picture will likely to increase.

```
library(forecast)
> temp1 <- ts(tp$tRI, frequency=12, start=1895)
> plot(temp1)
> plot(forecast(HoltWinters(temp1), h = 24))
> plot(forecast(HoltWinters(temp1), h = 24, xlab="
Year", ylab="Temperature in Fahrenheit"))
```

```
> pre1 <- ts(tp$pMS, frequency=12, start=1895)
> plot(pre1)
> plot(forecast(HoltWinters(pre1), h = 24, xlab="Y
ear", ylab="Precipitation in Inches"))
```

Library and Functions Used:

Libraries	Functions	Purpose
readxl	read_excel()	read excel data
lubridate	as.Date()	convert to a date
tidyverse	tibble()	convert date as string
dplyr	merge()	combine data
	aggregate()	select group, combine, can calculate average
	group_by()	group data
	filter()	filter data based on existing condition
	select()	select desired data
	arrange()	to sort
pastecs	stat.desc()	to provide statistical analysis
trend	sens.slope()	calculate sen slope
Kendall	Kendall()	calculate tau and p value
zyp	zyp.sen()	calculate sen slope
forecast	ts()	to group timeseries data based on given frequency
	HoltWinters()	to provide forecast information
	forecast()	to give forecast information based on timeseries
ggplot2	ggplot()	to graph (ggtitle/ geom_point(to add points)/geom_smooth()(to add line that is not linear)
pre-programmed	heatmap()	to generate heat map
	sort()	to sort
	hist()	to create histogram
	pie()	to create pie chart

CONCLUSION:

- Based on Mann-Kendall tests, the U.S is experiencing climate change.
- Temperature is increasing in most states in the U.S (41 states).
- Precipitation increase occurs in a little less than half of the U.S territories (24 states).

If the prediction model still stands years from now,

- If you are someone who likes "cold", you should not be moving to Rhode Island, New Jersey, and Connecticut years from now.
- If you are someone who enjoys dry season, you should not be moving to Mississippi, Louisiana, and Vermont years from now.