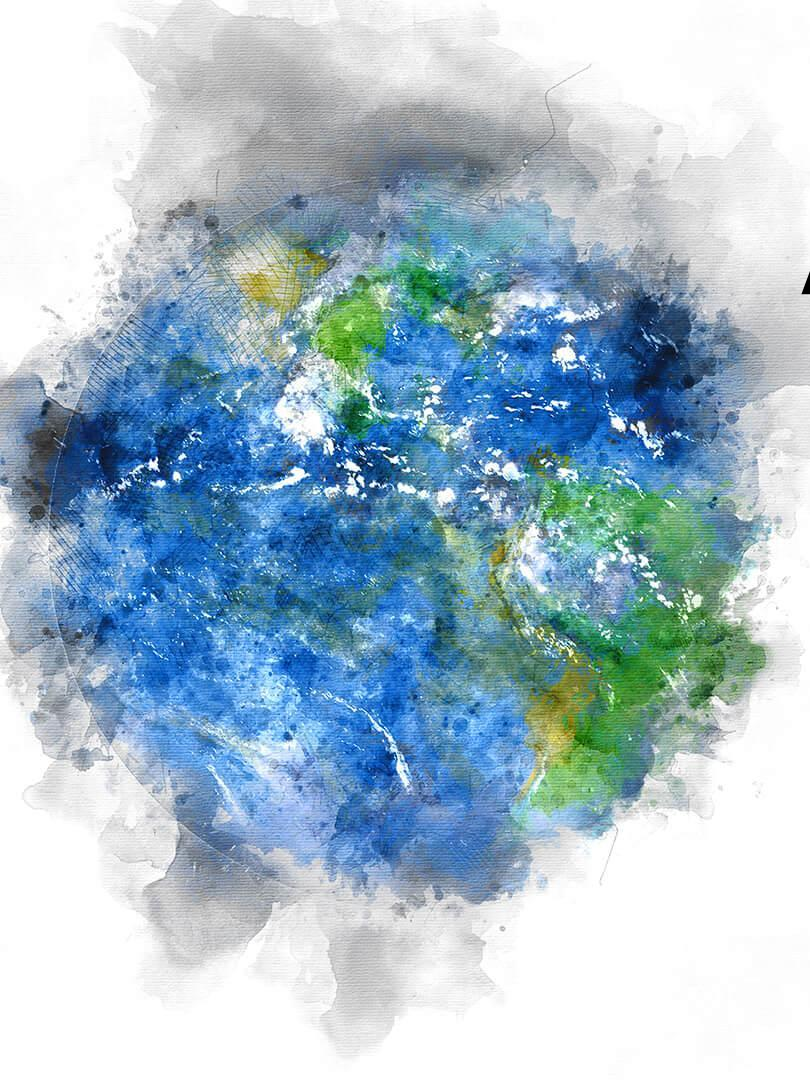
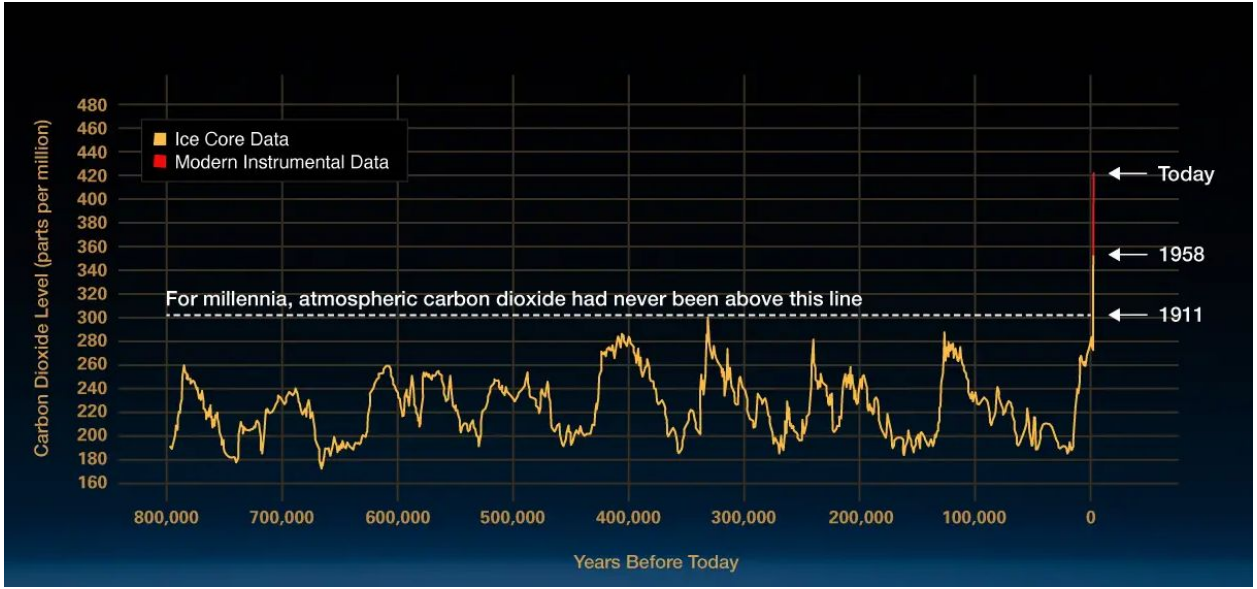


Analyzing Relationship Between Air Quality Index and Average Temperature in the United States from 2000-2019

Daniel Kim, Maximillian Jacob, Zachary Fenton

Introduction



Goal:

1. **Correlations**
2. **Recommendations**

Data/Merging

Two Primary Sources

1. EPA: ambient air quality
2. Washington Post: annual temperature

One Intermediate Source

3. Fips to CBSA conversion

1

	CBSA	CBSA Code	Year	Days with AQI	Good Days	Moderate Days	Unhealthy for Sensitive Groups Days	Unhealthy Days	Very Unhealthy Days	Hazardous Days	Max AQI	90th Percentile AQI	Median AQI	Days CO	Days NO2	Days Ozone	Days PM2.5	Days PM10
0	Aberdeen, SD	10100	2000	103	84	19	0	0	0	0	77	54	30	0	0	0	84	19
1	Adrian, MI	10300	2000	182	138	38	4	2	0	0	154	77	44	0	0	182	0	0
2	Aguadilla-Isabela, PR	10380	2000	92	87	5	0	0	0	0	73	35	22	0	0	0	92	0
3	Akron, OH	10420	2000	366	98	238	27	3	0	0	185	93	60	2	0	88	271	5
4	Alamogordo, NM	10460	2000	56	54	2	0	0	0	0	56	34	16	0	0	0	0	56

2

	fips	Year	temp	tempc
0	01001	1895	62.633333	17.018519
1	01001	1896	65.341667	18.523148
2	01001	1897	65.150000	18.416667
3	01001	1898	63.816667	17.675926
4	01001	1899	63.925000	17.736111

Data Cleaning and Sanity Check

Fips	Year	Temp	Tempc	Cbsa_code	Csacode	Cbsatitle	Csatitle	County	Statename	Fipsstatecode	Fipscountycode	Cbsa	Days_with_aqi	Good_days	Moderate_days	Unhealthy_for_sensitive_groups_days	Unhealthy_days	Very_unhealthy_days	Hazardous_days	Max_aqi	90th_percentile_aqi	Median_aqi	Days_co	Days_no2	Days_ozone	Days_pm2_5	Days_pm10
1001	2000	64.33333333	17.96296296	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	282	113	115	48	6	0	0	195	115	57	0	0	200	81	1
1051	2000	64.11666667	17.84259259	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	282	113	115	48	6	0	0	195	115	57	0	0	200	81	1
1085	2000	65.09166667	18.38425926	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	282	113	115	48	6	0	0	195	115	57	0	0	200	81	1
1101	2000	64.94166667	18.30092593	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	282	113	115	48	6	0	0	195	115	57	0	0	200	81	1
1001	2001	63.75833333	17.64351852	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	285	159	110	15	1	0	0	154	84	48	0	0	191	90	4
1051	2001	63.625	17.56944444	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	285	159	110	15	1	0	0	154	84	48	0	0	191	90	4
1085	2001	64.475	18.04166667	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	285	159	110	15	1	0	0	154	84	48	0	0	191	90	4
1101	2001	64.34166667	17.96759259	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	285	159	110	15	1	0	0	154	84	48	0	0	191	90	4
1001	2002	64.35	17.97222222	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	316	193	109	12	2	0	0	164	84	45	0	0	190	91	35
1051	2002	64.29166667	17.93981481	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	316	193	109	12	2	0	0	164	84	45	0	0	190	91	35
1085	2002	65.00833333	18.33796296	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	316	193	109	12	2	0	0	164	84	45	0	0	190	91	35
1101	2002	64.9	18.27777778	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	316	193	109	12	2	0	0	164	84	45	0	0	190	91	35
1001	2003	63.48333333	17.49074074	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	284	175	102	7	0	0	0	143	80	46	0	0	184	100	0
1051	2003	63.50833333	17.50462963	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	284	175	102	7	0	0	0	143	80	46	0	0	184	100	0
1085	2003	64.26666667	17.92592593	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	284	175	102	7	0	0	0	143	80	46	0	0	184	100	0
1101	2003	64.29166667	17.93981481	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	284	175	102	7	0	0	0	143	80	46	0	0	184	100	0
1001	2004	64.3	17.94444444	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	284	179	98	7	0	0	0	129	77	46	0	0	188	96	0
1051	2004	64.05	17.80555556	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	284	179	98	7	0	0	0	129	77	46	0	0	188	96	0
1085	2004	64.88333333	18.26851852	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	284	179	98	7	0	0	0	129	77	46	0	0	188	96	0
1101	2004	64.825	18.23611111	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	284	179	98	7	0	0	0	129	77	46	0	0	188	96	0
1001	2005	64.025	17.79166667	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	285	168	114	3	0	0	0	133	79	48	0	0	183	102	0
1051	2005	63.83333333	17.68518519	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	285	168	114	3	0	0	0	133	79	48	0	0	183	102	0
1085	2005	64.55833333	18.08796296	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	285	168	114	3	0	0	0	133	79	48	0	0	183	102	0
1101	2005	64.55833333	18.08796296	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	285	168	114	3	0	0	0	133	79	48	0	0	183	102	0
1001	2006	64.96666667	18.31481481	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	286	152	122	11	1	0	0	175	84	49	0	0	193	93	0
1051	2006	64.73333333	18.18518519	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	286	152	122	11	1	0	0	175	84	49	0	0	193	93	0
1085	2006	65.4	18.55555556	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	286	152	122	11	1	0	0	175	84	49	0	0	193	93	0
1101	2006	65.41666667	18.56481481	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	286	152	122	11	1	0	0	175	84	49	0	0	193	93	0
1001	2007	65.25833333	18.47685185	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	353	154	180	14	5	0	0	157	87	54	0	0	128	225	0
1051	2007	64.925	18.29166667	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	353	154	180	14	5	0	0	157	87	54	0	0	128	225	0
1085	2007	65.575	18.65277778	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	353	154	180	14	5	0	0	157	87	54	0	0	128	225	0
1101	2007	65.48333333	18.60185185	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	353	154	180	14	5	0	0	157	87	54	0	0	128	225	0
1001	2008	63.79166667	17.66203704	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	349	188	157	4	0	0	0	122	77	48	0	0	114	234	1
1051	2008	63.55833333	17.53240741	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	349	188	157	4	0	0	0	122	77	48	0	0	114	234	1
1085	2008	64.26666667	17.92592593	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	349	188	157	4	0	0	0	122	77	48	0	0	114	234	1
1101	2008	64.275	17.93055556	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	349	188	157	4	0	0	0	122	77	48	0	0	114	234	1
1001	2009	63.775	17.65277778	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	323	216	107	0	0	0	0	93	64	44	0	0	100	223	0
1051	2009	63.56666667	17.53703704	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	323	216	107	0	0	0	0	93	64	44	0	0	100	223	0
1085	2009	64.29166667	17.93981481	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	323	216	107	0	0	0	0	93	64	44	0	0	100	223	0
1101	2009	64.275	17.93055556	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	323	216	107	0	0	0	0	93	64	44	0	0	100	223	0
1001	2010	63.59166667	17.55092593	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	364	184	172	8	0	0	0	129	71	50	0	0	120	243	1
1051	2010	63.35833333	17.4212963	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	364	184	172	8	0	0	0	129	71	50	0	0	120	243	1
1085	2010	64.00833333	17.78240741	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	364	184	172	8	0	0	0	129	71	50	0	0	120	243	1
1101	2010	63.85833333	17.69907407	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	364	184	172	8	0	0	0	129	71	50	0	0	120	243	1
1001	2011	64.65833333	18.14351852	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Autauga	Alabama	1	1	Montgomery, AL	283	179	101	3	0	0	0	108	77	45	0	0	202	81	0
1051	2011	64.50833333	18.06018519	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Elmore	Alabama	1	51	Montgomery, AL	283	179	101	3	0	0	0	108	77	45	0	0	202	81	0
1085	2011	65.25833333	18.47685185	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Lowndes	Alabama	1	85	Montgomery, AL	283	179	101	3	0	0	0	108	77	45	0	0	202	81	0
1101	2011	65.16666667	18.42592593	33860	388	Montgomery, AL	Montgomery-Selma-Alexander City, AL	Montgomery	Alabama	1	101	Montgomery, AL	283	179	101	3	0	0	0	108	77	45	0	0	202	81	0

Data Cleaning and Sanity Check cont.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Number of States	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49	49

Number of states in each year

- This table shows that the number of states over the time period does not change.

Statename	Florida	Louisiana	Texas	Mississippi	Alabama	Georgia	South Carolina	Arizona	Arkansas	Oklahoma	California	North Carolina	Tennessee	Virginia	District of Columbia	Kentucky	Delaware	Maryland	Kansas	Missouri	New Mexico	New Jersey	West Virginia	Indiana	Illinois	Ohio	Nevada	Rhode Island	Pennsylvania	Nebraska	Connecticut	Oregon
Temp	71.39	67.95	67.29	64.45	63.53	63.31	62.98	62.68	61.04	60.99	59.59	59.33	58.74	57.12	56.97	56.30	56.24	56.12	55.65	55.28	54.50	53.76	53.58	52.77	52.44	51.80	51.43	51.14	50.69	50.20	50.16	49.62

Average temperature of each state over entire dataframe

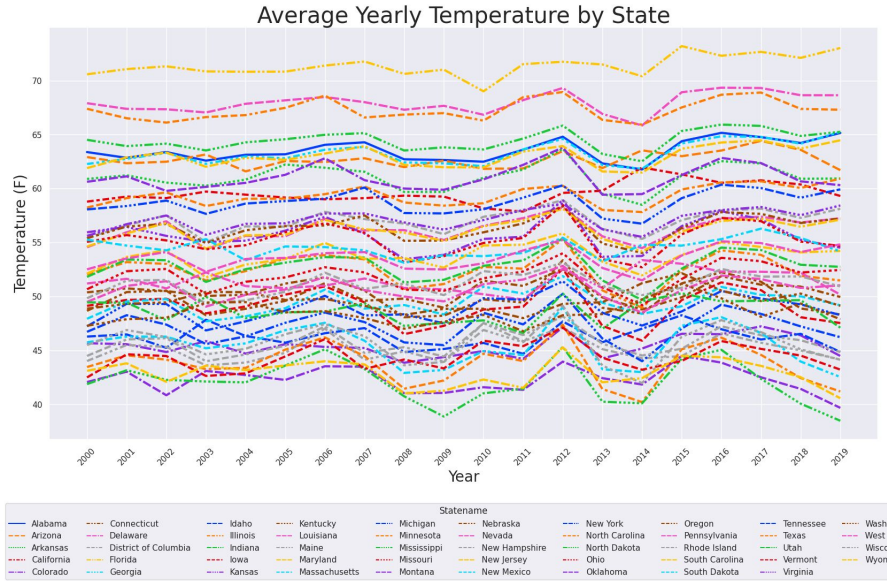
- This table (subset of full table) is a gut check of temperature data.
  - Can see that Florida has the warmest average temperature, which is expected.
  - Provides high level validity to data.

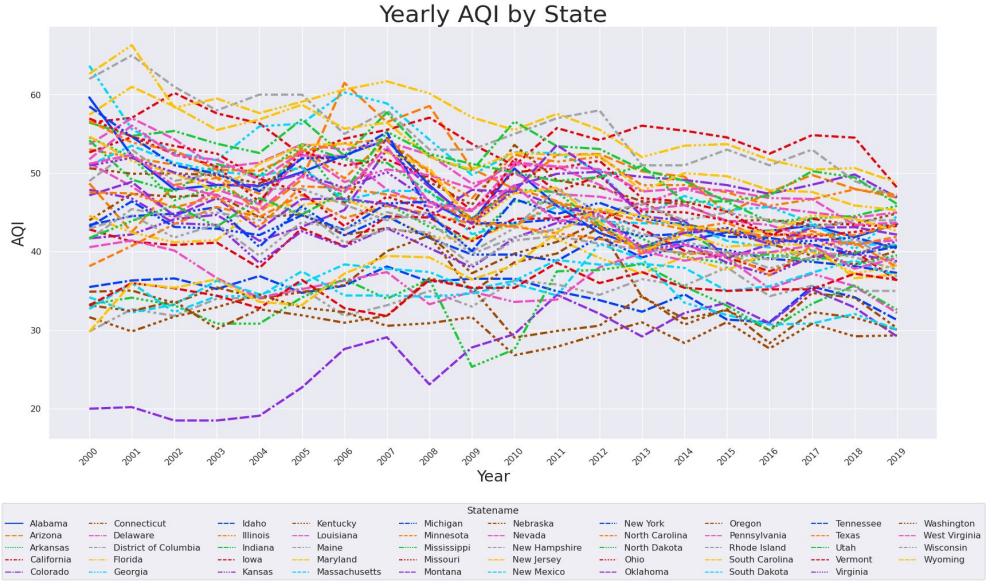
Data Cleaning and Sanity Check cont.

Number of reporting sites per state by year

Statename	Alabama	Arizona	Arkansas	California	Colorado	Connecticut	Delaware	District of Columbia	Florida	Georgia	Idaho	Illinois	Indiana	Iowa	Kansas	Kentucky	Louisiana	Maine	Maryland	Massachusetts	Michigan	Minnesota	Mississippi
Year																							
2000	31	10	30	45	26	8	3	1	41	75	20	41	55	25	17	49	39	6	18	12	37	33	33
2001	31	10	30	45	26	8	3	1	43	75	21	42	55	26	17	50	39	6	18	12	38	31	34
2002	31	10	30	44	23	8	3	1	42	77	22	42	54	26	22	50	39	6	18	12	37	25	35
2003	32	10	30	44	23	8	3	1	42	78	20	42	53	26	23	49	39	6	18	13	36	28	34
2004	33	10	25	44	23	8	3	1	42	78	20	42	51	26	23	49	39	6	18	13	36	27	34
2005	33	10	22	44	23	8	3	1	42	78	20	42	51	26	23	48	39	6	18	13	36	29	34
2006	32	10	24	44	23	8	3	1	42	78	18	42	51	26	23	48	37	6	18	13	35	29	32
2007	30	10	24	44	23	8	3	1	42	77	18	42	51	26	21	44	37	6	18	13	35	29	32
2008	30	9	24	44	23	8	3	1	44	77	18	42	51	26	22	44	37	6	18	13	35	29	32
2009	30	9	24	44	25	8	3	1	44	77	18	42	51	26	22	44	37	6	18	13	35	29	32
2010	30	9	24	44	23	8	3	1	44	77	20	42	51	26	21	44	37	6	18	13	35	29	31
2011	30	9	24	44	24	8	3	1	44	77	20	39	51	26	21	44	37	6	18	13	34	29	31
2012	30	9	23	44	24	8	3	1	44	77	17	39	51	26	21	42	36	6	18	13	34	29	29
2013	30	9	20	44	23	8	3	1	44	77	17	39	51	26	21	42	36	6	18	13	34	29	27
2014	30	9	20	44	23	8	3	1	44	77	14	39	53	26	18	42	36	6	18	13	34	30	27
2015	30	9	20	44	23	8	3	1	44	77	20	39	53	26	18	42	36	6	18	13	34	30	28
2016	30	9	20	44	25	8	3	1	44	77	20	39	52	26	18	42	36	6	18	13	34	30	28
2017	30	9	20	44	25	8	3	1	44	77	20	39	52	24	18	42	36	6	18	13	34	30	28
2018	29	9	22	44	25	8	3	1	44	77	20	39	52	24	18	40	36	6	18	13	34	30	28
2019	29	9	22	44	22	8	3	1	44	77	20	39	52	24	18	40	36	6	18	13	34	30	27

Initial Exploration





Comparing each state's:

- Average yearly temperature change
- Median AQI change

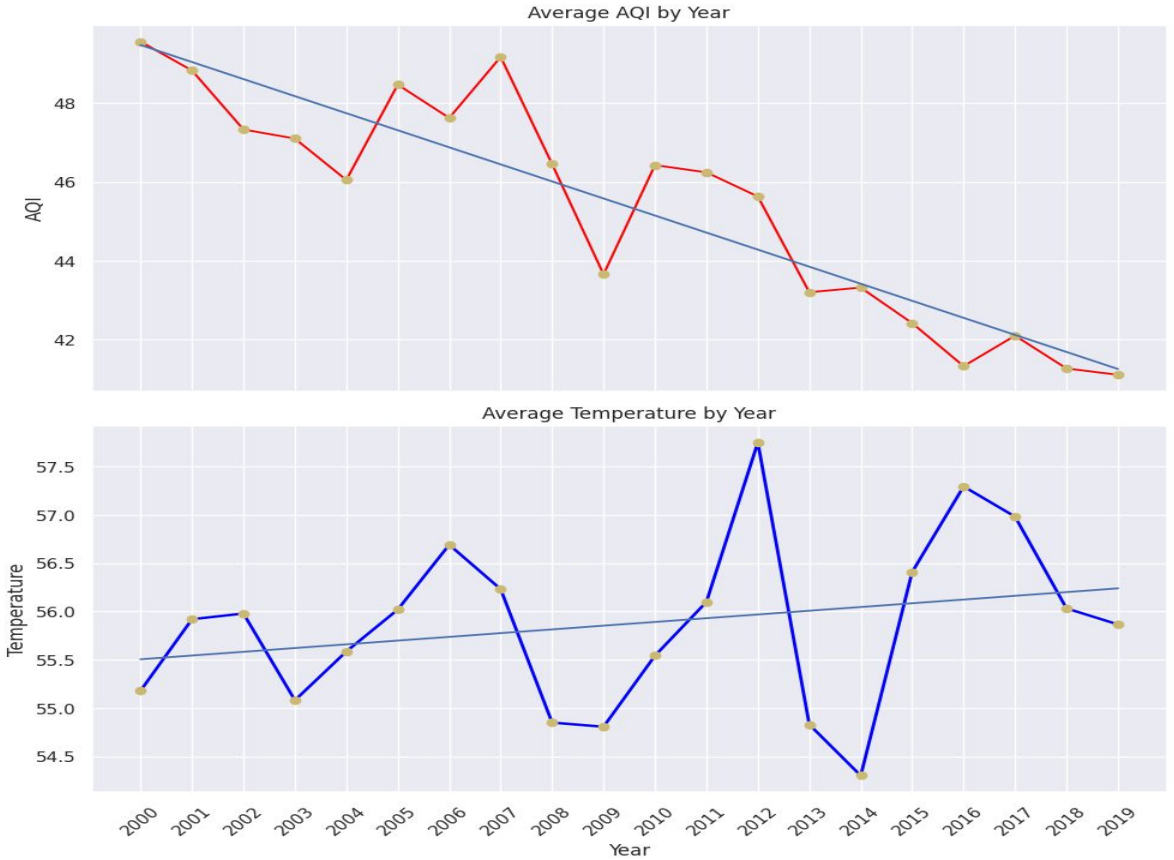
Initial Exploration

First we looked at states individually:

- Change in Average AQI vs Time.
- Change in Average Temperature vs time.

Next we looked at US as a whole:

- Change in Average AQI vs Time.
- Change in Average Temperature vs time.



Annual Temperature Change

1 Mean Temp:

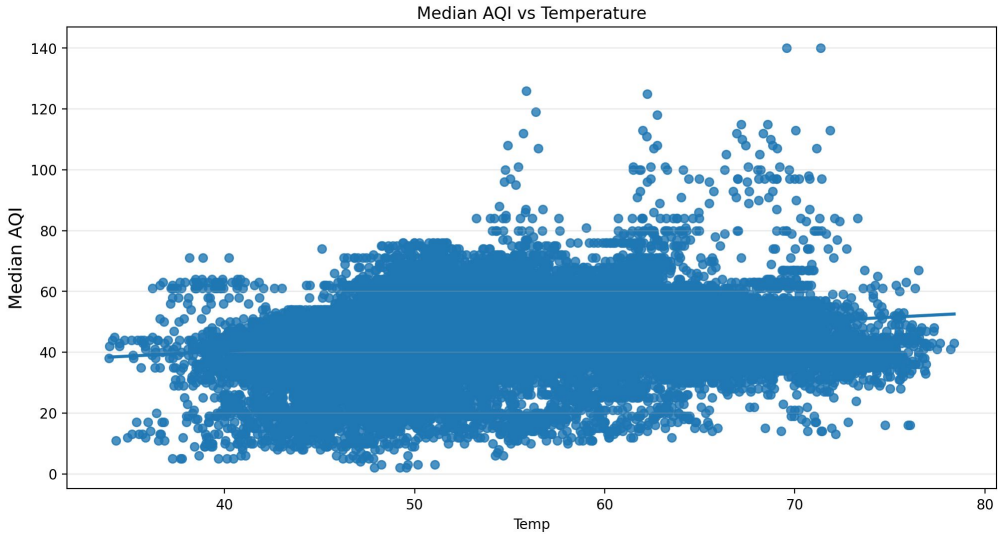
- Slight increase ~0.5 F over 19 year period
- Periodicity observed in data

2 Temp Standard Deviation

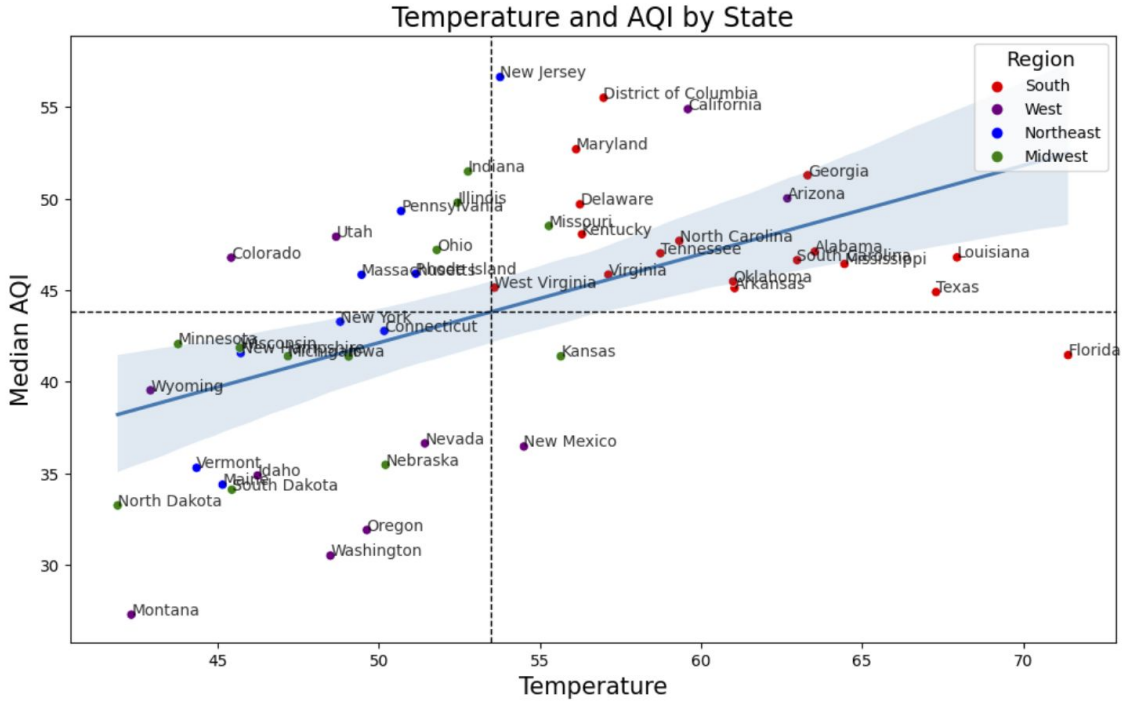
- Overall increase in temperature standard deviation y.o.y

Temperature vs AQI

No Clear Correlation between Temperature and AQI in bulk data

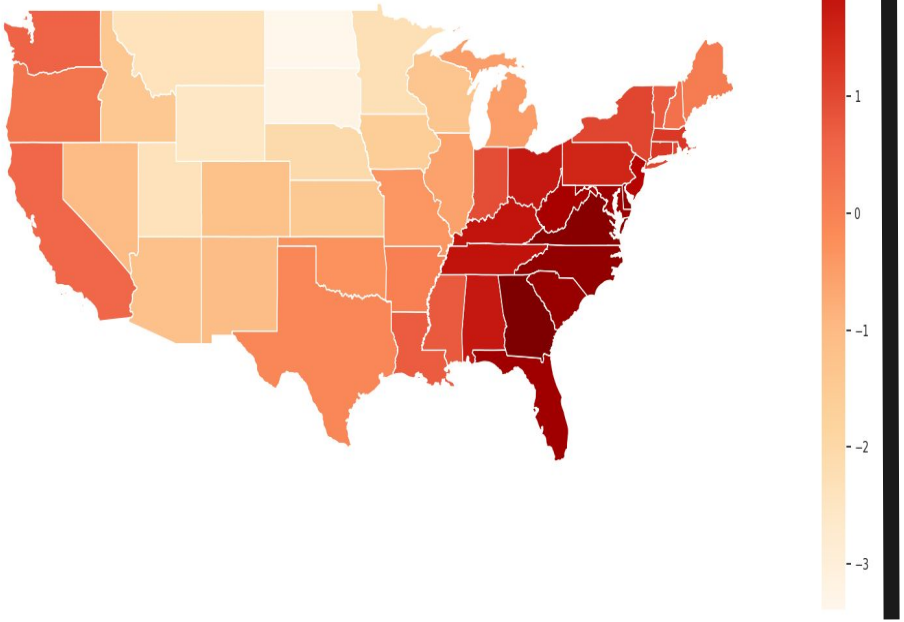


Analysis

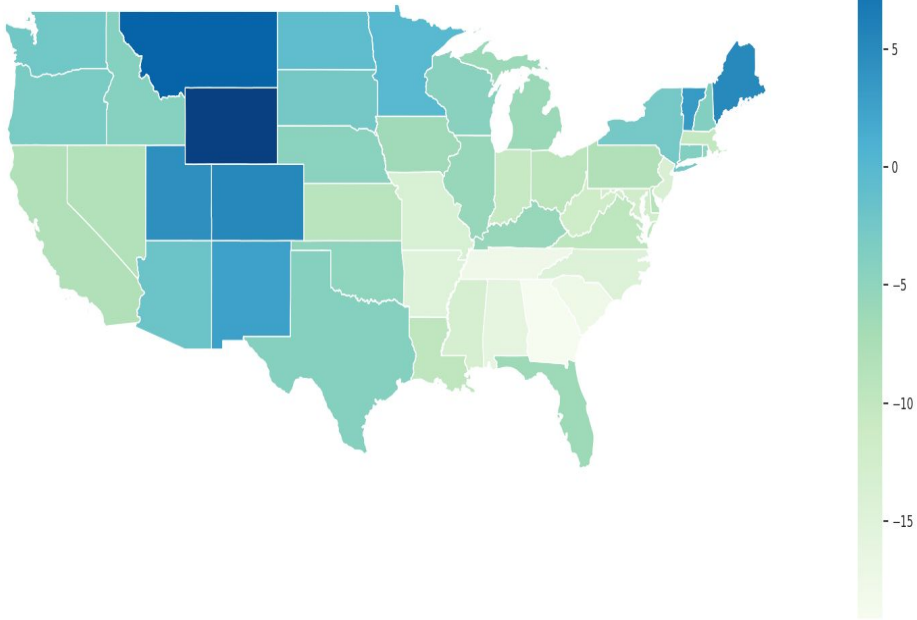

Temperature and AQI by State
Region
South
West
Northeast
Midwest
Median AQI
Temperature
55
50
45
40
35
30
45
50
55
60
65
70
New Jersey
District of Columbia
California
Maryland
Indiana
Georgia
Arizona
Delaware
Illinois
Pennsylvania
Missouri
Kentucky
Utah
North Carolina
Tennessee
Alabama
Louisiana
Colorado
Ohio
Virginia
Oklahoma
Arkansas
Texas
West Virginia
New York
Connecticut
Minnesota
Kansas
Florida
Wyoming
Nevada
New Mexico
Vermont
Nebraska
Idaho
South Dakota
North Dakota
Oregon
Washington
Montana

Analysis

Average Temperature difference between 2000 and 2019



Median AQI difference between 2000 and 2019



Conclusion

- **Geographical and Environmental Interplay**: Southern states have higher AQI values due to warmth and urbanization, while cooler Western and Midwestern states generally show lower AQI with the exception of California and Arizona. Northeastern states maintain median AQI levels potentially influenced by their temperate climates.
- **Potential Temperature Shifts**: Average temperatures in the U.S. have noticeably changed, highlighting the widespread effects of global climate change. Over the 19-year period, there appears to be a consistent warming trend. Additionally, a global event such as 2012's La Nina may have important contribution to the variation in this observation.
- **Topographical Potential Influence on AQI**: The Western U.S., particularly the Rocky Mountain region, is witnessing a surge in AQI levels. The unique topographical features of mountain ranges may act as barriers, hindering the natural dispersal of pollutants by coastal winds.

Final recommendation

- **Studies on periodicity in temperature data** - if extreme points can be understood, then additional mitigation measures may be discovered
- **Prioritize focus on Southeast US for temperature studies**, and **Midwest for AQI studies** due to the relative higher increases in both metrics across these regions
- **Exploration into adaptive infrastructures** - for instance, the integration of heat-resistant materials for roads and enhanced cooling systems might counteract the repercussions of extreme temperatures.
- **Examination of temperature's influence on species' behaviors** - understanding how fluctuations affect breeding and migration could prevent imbalances in local ecosystems.