

Atlantic Hurricanes Frequency EDA

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Abstract

In this work, we try to explore the frequencies of category 4[Wikd] as well as category 5[Wike] hurricanes observed since 1853 in the Atlantic. The objective is to try multiple approaches to understand trends in the hurricane frequencies, and possibly correlate their distribution to environmental factors.

1 Problem Statement

This is exploratory data analysis, look at the data in as clever a collection of ways as you can, and try to pull out what it can tell you. Could it reflect information on change in technology? Could it contain information on climate change? Could possible sources of variation in what you see be interfering (technically "confounding") each other?

2 Solution

2.1 Correlation with Environmental factors

We tried to correlate the hurricane frequencies against the following indexes.

- Atlantic Multidecadal Oscillation : Atlantic Multidecadal Oscillation (AMO)[Atm] is a climate cycle that affects the sea surface temperature of the North Atlantic Ocean based on different modes on multidecadal timescales. The AMO is correlated to air temperatures and rainfall over much of the Northern Hemisphere, in particular in the summer climate in North America and Europe. It is also associated with changes in the frequency of North American droughts and is reflected in the frequency of severe Atlantic hurricane activity[Wika].
For our analysis, we used the data from 1948 to 2020[PSL] provided by NOAA Physical Sciences Laboratory.
- National Temperature Index by ClimDiv : This time series is provided by NOAA Climate Division (CLimDiv) and records minimum, maximum and average temperature anomalies over different time scales.
For this analysis, we used the ClimDiv index for average temperature anomaly over a year(in degrees Fahrenheit) from 1895 to 2020[Env].
- Carbon emissions : The present concentration of carbon dioxide in the atmosphere is the highest for 14 million years. The increase has been attributed to human activity, particularly deforestation and the burning of fossil fuels. CO2 emissions have been held responsible for the current episode of global warming, as well as changes to oceanic activity and the weather cycle in general[Wikb].
For this analysis, we used the CO2 emissions data (in metric tons per capita) provided by World Bank for USA from 1960 to 2016[Ban].

For capturing any high level observable trends, we first plotted the hurricane frequency against time, while also plotting the values for the indices above for the same time range. The analysis was done both year-wise and decade-wise, and for both category 4(add reference) and category 5(add reference) hurricanes. Wherever environmental indices data was available monthly we averaged over each year to get the yearly series, and similarly averaged over years to get decade-wise series. Filtering was applied to hurricane frequency time series to match the available time range of indices data.

We then performed correlation test[Wikc] between the series of each index values and hurricane frequency using *Pearson's product-moment correlation* (sensitive only to a relationship between two variables, which may be present even when one variable is a non function of the other), *Kendall's rank correlation tau* (measure of rank correlation, that is, the similarity of the orderings of the data when ranked by each of the quantities), and *Spearman's rank correlation rho* (more robust than Pearson's, that is, more sensitive to non relationships). A value of +1 is total positive correlation, 0 is no correlation, and -1 is total negative correlation. So all three correlations agreeing and taking values closer to +1 or -1 is indicative of some strong correlation between the variables. Otherwise we may reasonably conclude that the variables are weakly correlated or show no correlation at all.

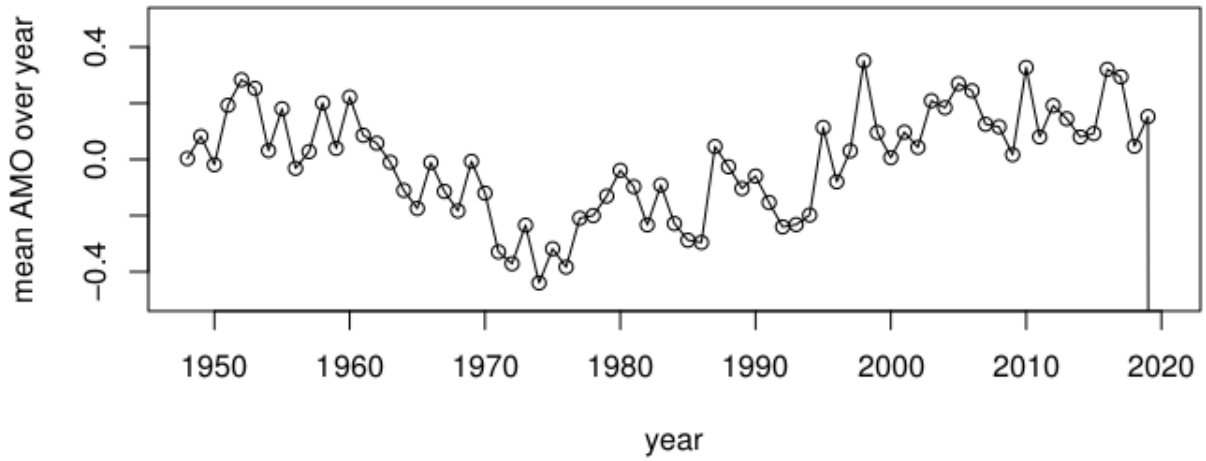
We used R for the scripting. The plots and correlation results observed are presented below.

2.1.1 Hurricane Frequencies and Atlantic Multidecadal Oscillation

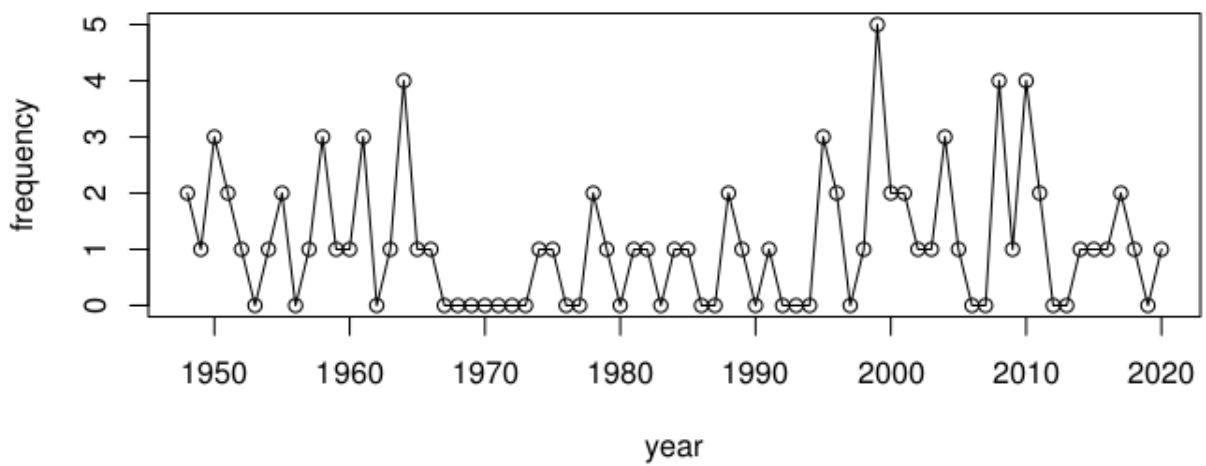
Var1	Var2	Series Type	Pearson	Kendall	Spearman	Observation
mean AMO	frequency (Category 4)	Yearly	0.02503082	0.2424317	0.3182891	No correlation
mean AMO	frequency (Category 5)	Yearly	0.0776471	0.195678	0.2511009	No correlation
mean AMO	frequency (Category 4)	Decade	0.7158199	0.7042952	0.8451957	Strong Positive correlation
mean AMO	square root of frequency (Category 5)	Decade	0.5843461	0.3771683	0.5148092	Weak Positive correlation

Table 1: Hurricane Frequencies vs mean AMO

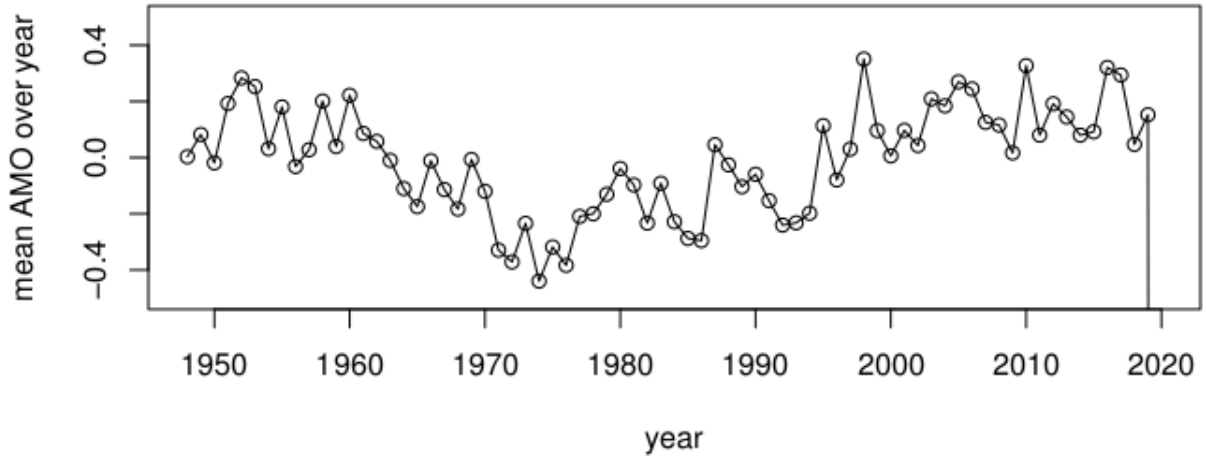
Category 4 By Year



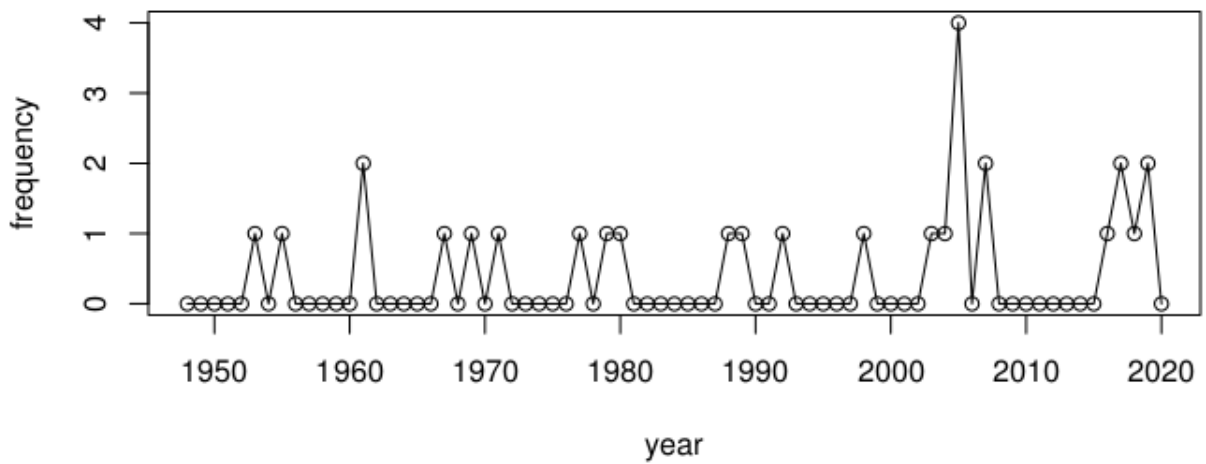
Category 4 By Year

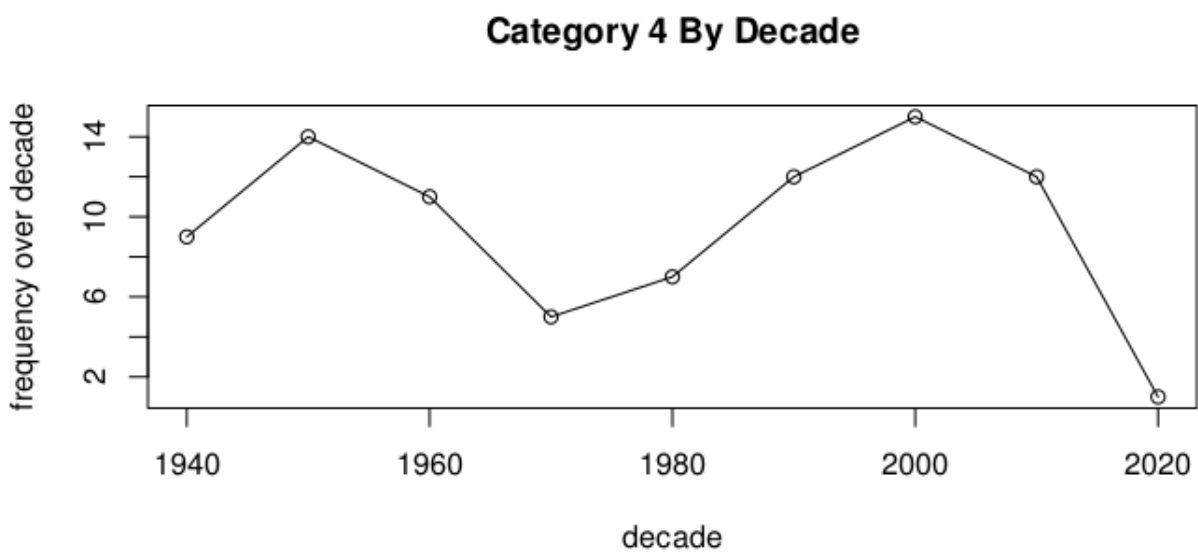
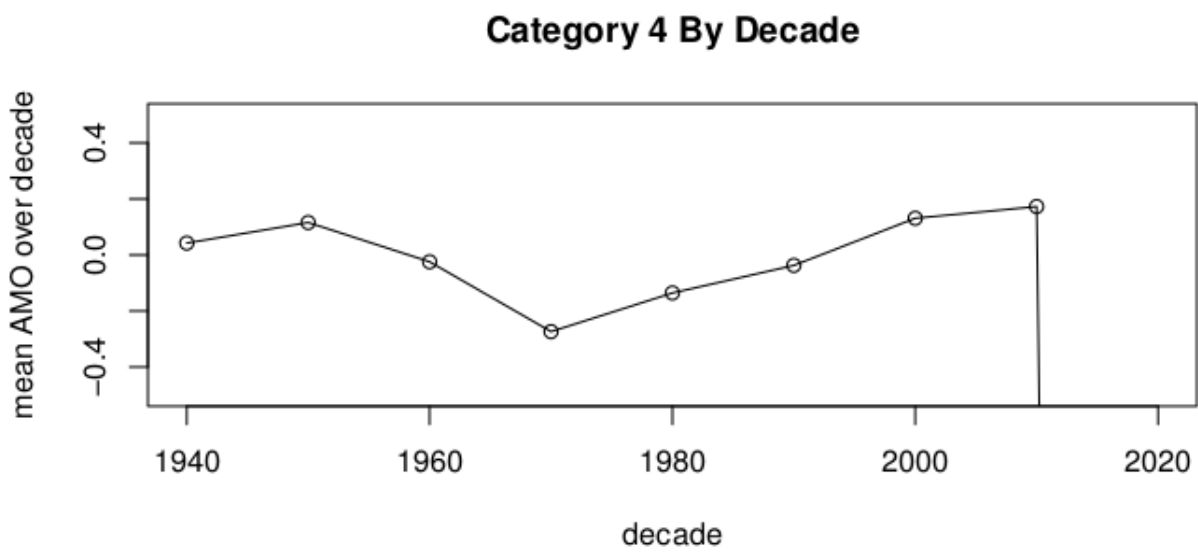


Category 5 By Year

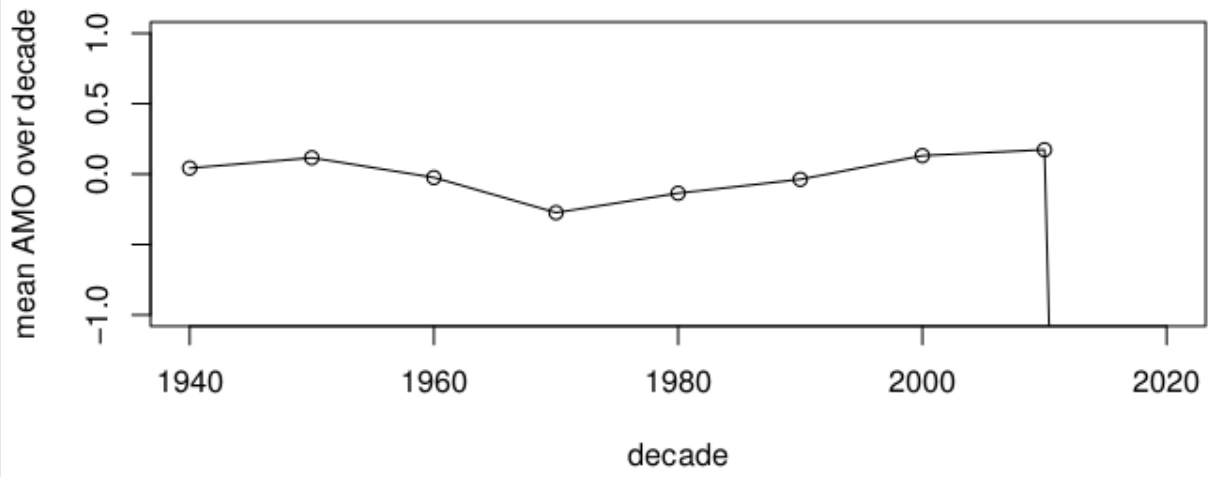


Category 5 By Year

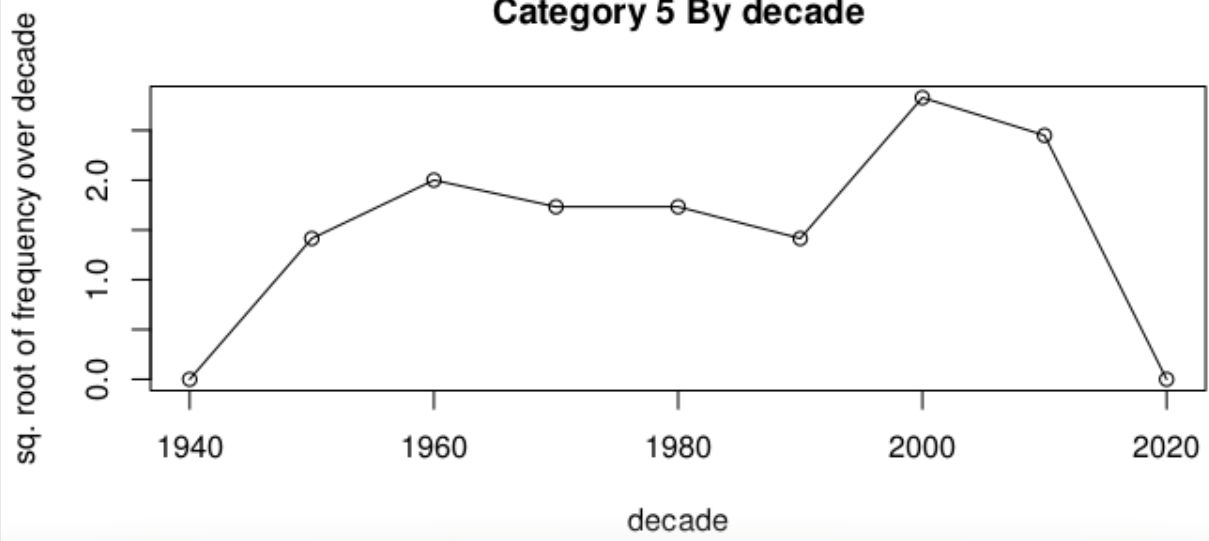




Category 5 By decade



Category 5 By decade



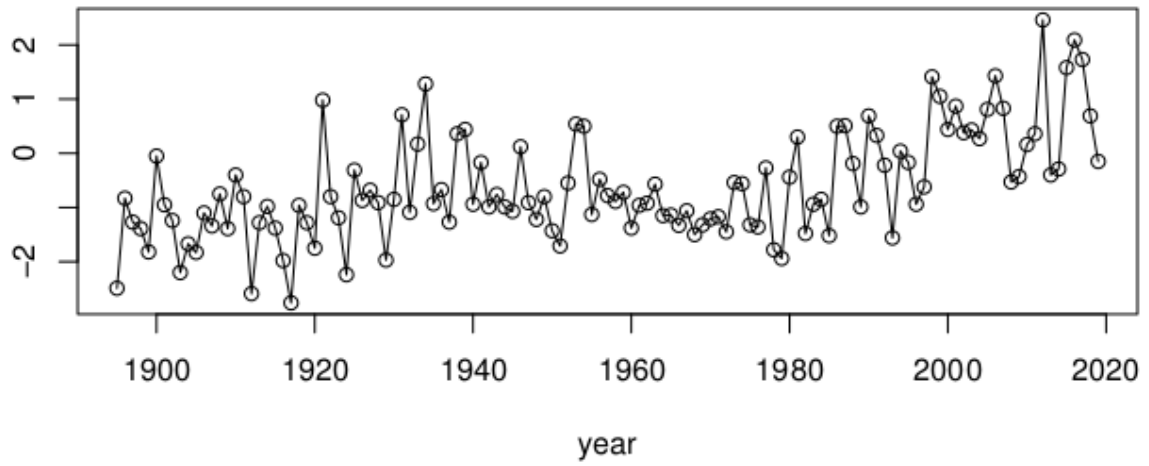
2.1.2 Hurricane Frequencies and National Temperature Index

Var1	Var2	Series Type	Pearson	Kendall	Spearman	Observation
Avg. Temp. Anomaly	frequency (Category 4)	Yearly	0.1188948	0.08415911	0.111953	No correlation
Avg. Temp. Anomaly	frequency (Category 5)	Yearly	0.247442	0.1711607	0.2119703	No correlation
Avg. Temp. Anomaly	frequency (Category 4)	Decade	0.7405665	0.6494054	0.8154301	Strong Positive correlation
Avg. Temp. Anomaly	frequency (Category 5)	Decade	0.7719905	0.5671516	0.7108537	Strong Positive correlation

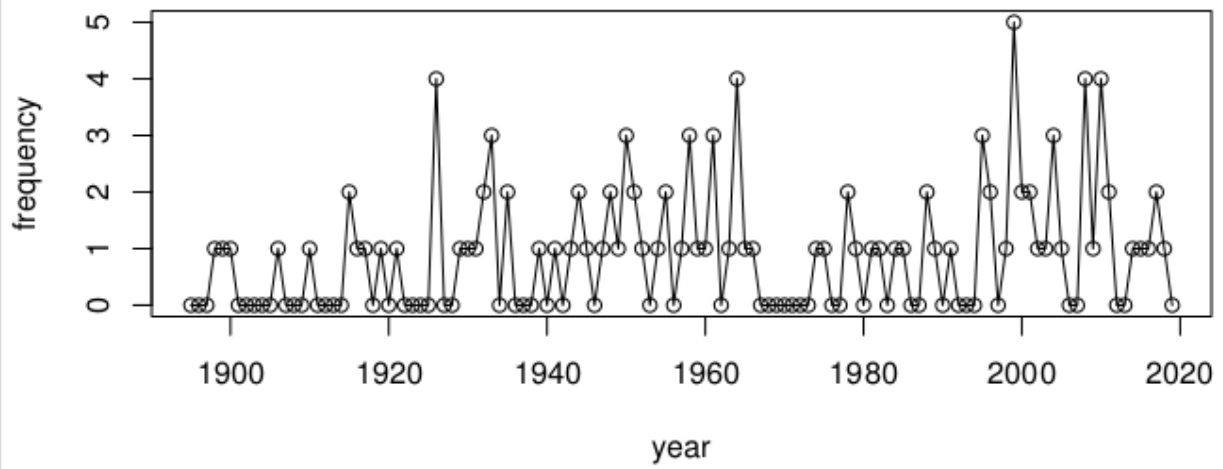
Table 2: Hurricane Frequencies vs Avg Temperature Anomaly (degree Fahrenheit)

Avg Temp Anomaly over year (deg F)

Category 4 By Year

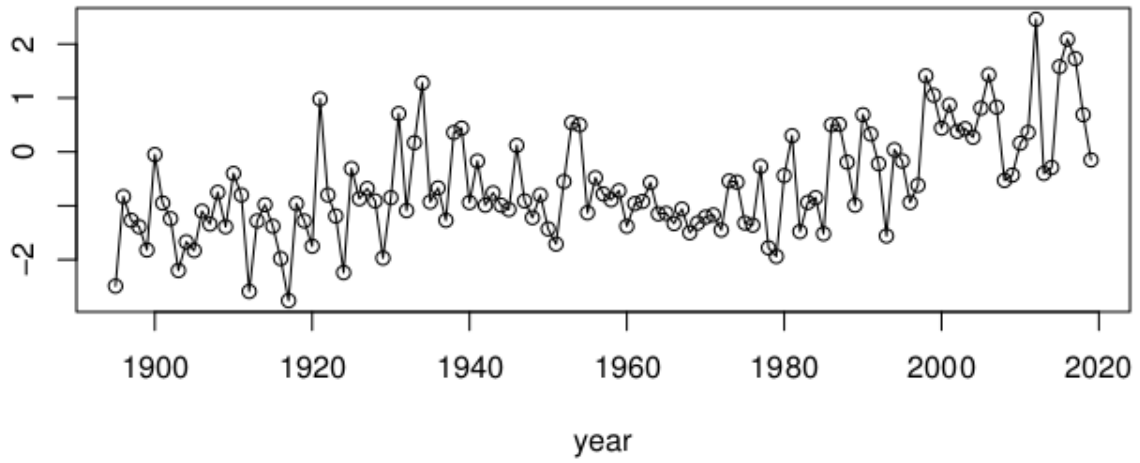


Category 4 By Year

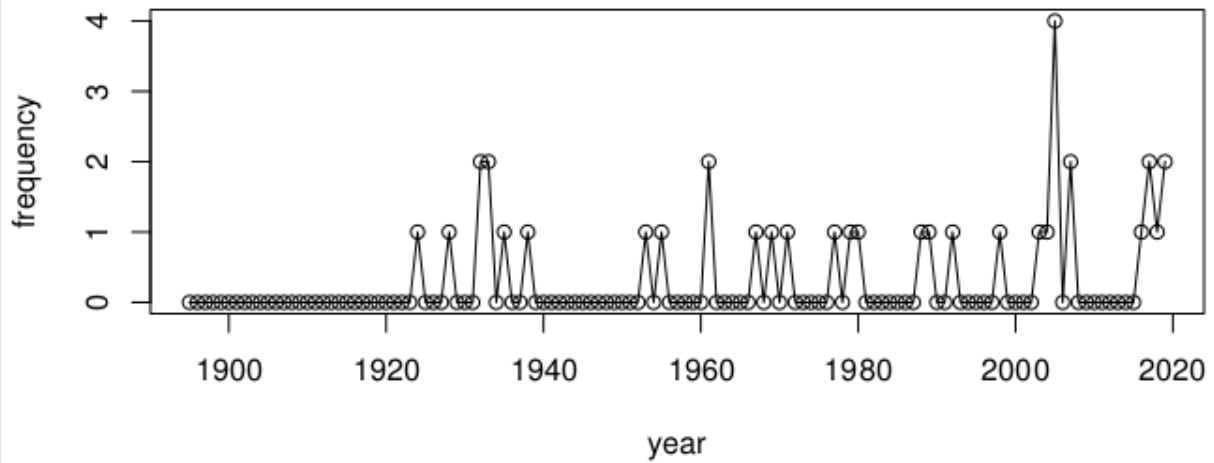


Avg Temp Anomaly over year (deg F)

Category 5 By Year

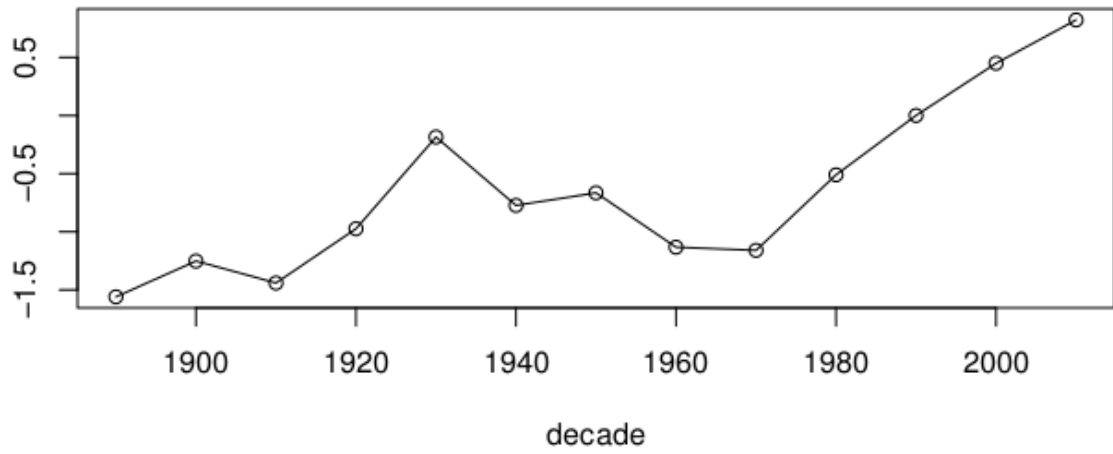


Category 5 By Year



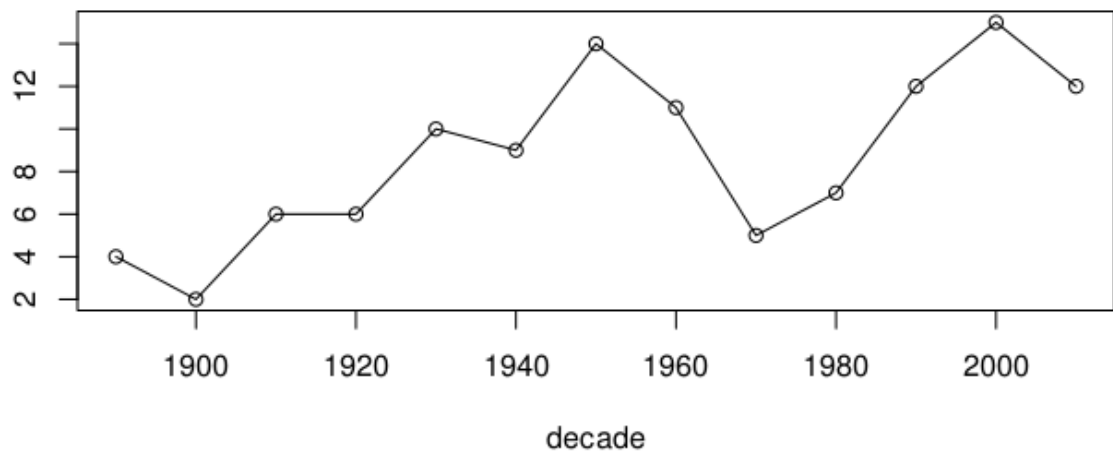
Avg Temp Anomaly over decade (deg F)

Category 4 By Decade



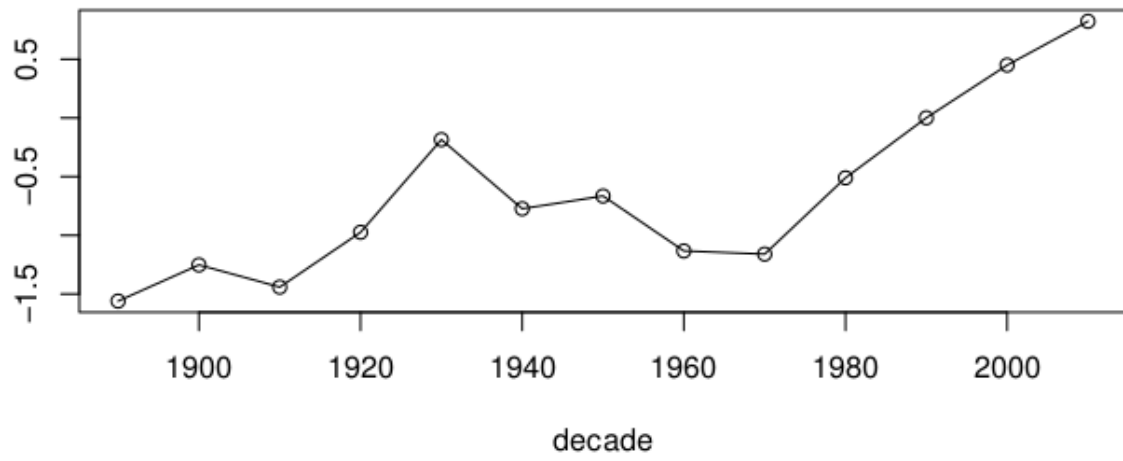
frequency over decade

Category 4 By Decade



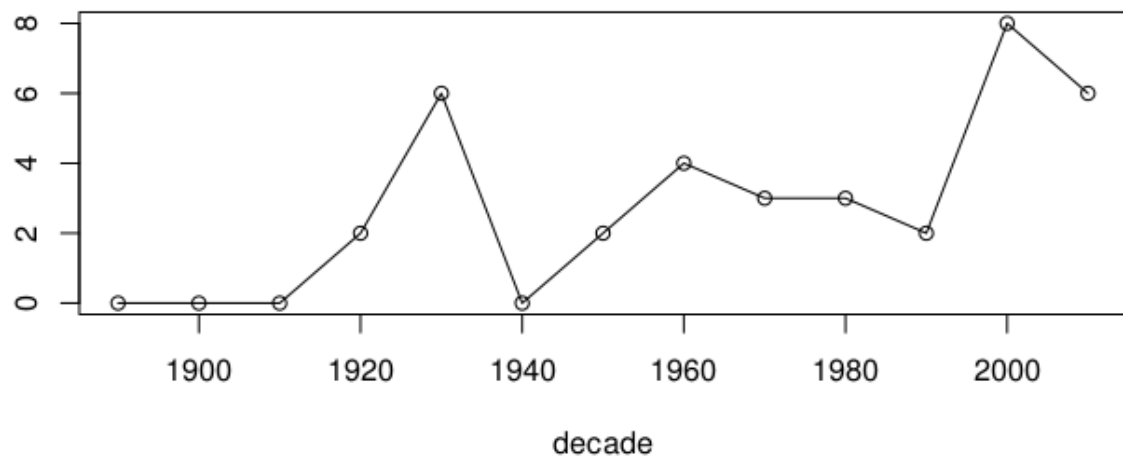
Avg Temp Anomaly over decade (deg F)

Category 5 By decade



frequency over decade

Category 5 By decade



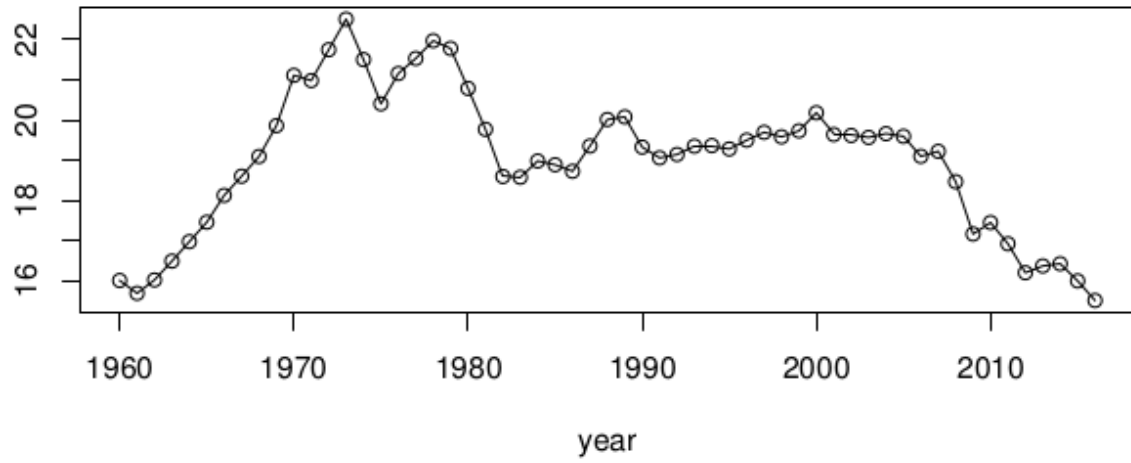
2.1.3 Hurricane Frequencies and CO2 emissions

Var1	Var2	Series Type	Pearson	Kendall	Spearman	Observation
Avg emission	frequency (Category 4)	Yearly	-0.1728431	-0.1035882	-0.1373616	No correlation
Avg emission	frequency (Category 5)	Yearly	0.08407722	0.1564412	0.1923625	No correlation
Avg emission	frequency (Category 4)	Decade	-0.5584973	-0.4140393	-0.4928054	Weak Negative correlation
Avg emission	square root of frequency (Category 5)	Decade	-0.3886657	-0.5520524	-0.7247138	Weak Negative correlation

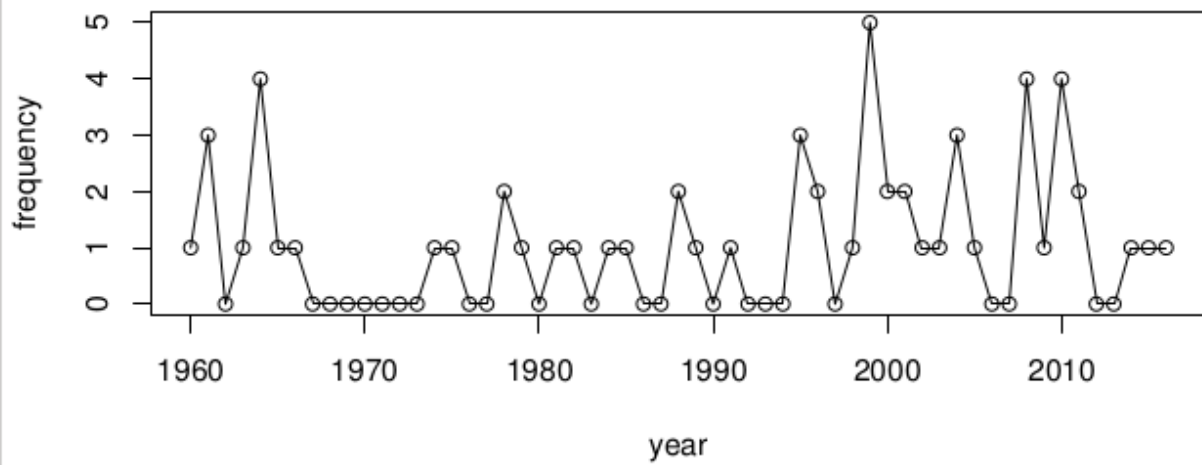
Table 3: Hurricane Frequencies vs avg CO2 emissions (metric tons per capita)

Avg emission over year (metric tons per capita)

Category 4 By Year

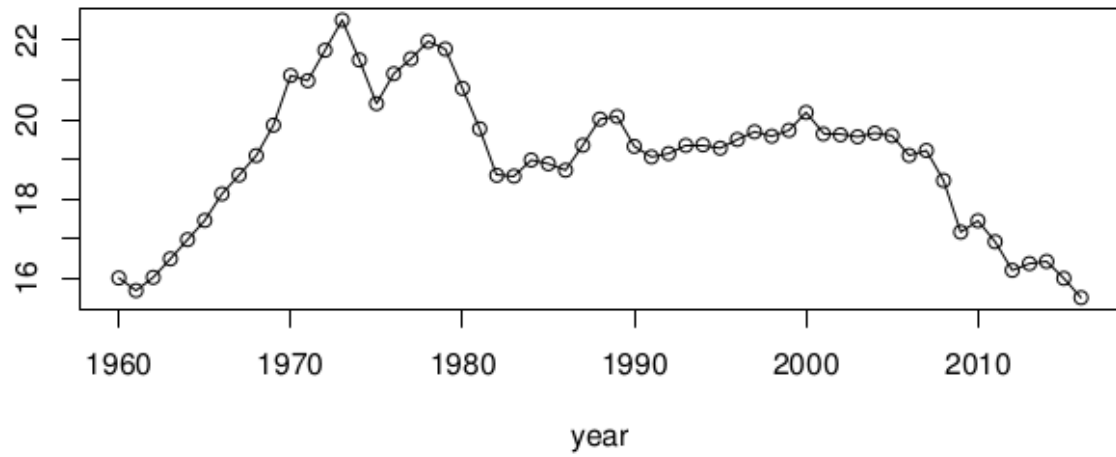


Category 4 By Year

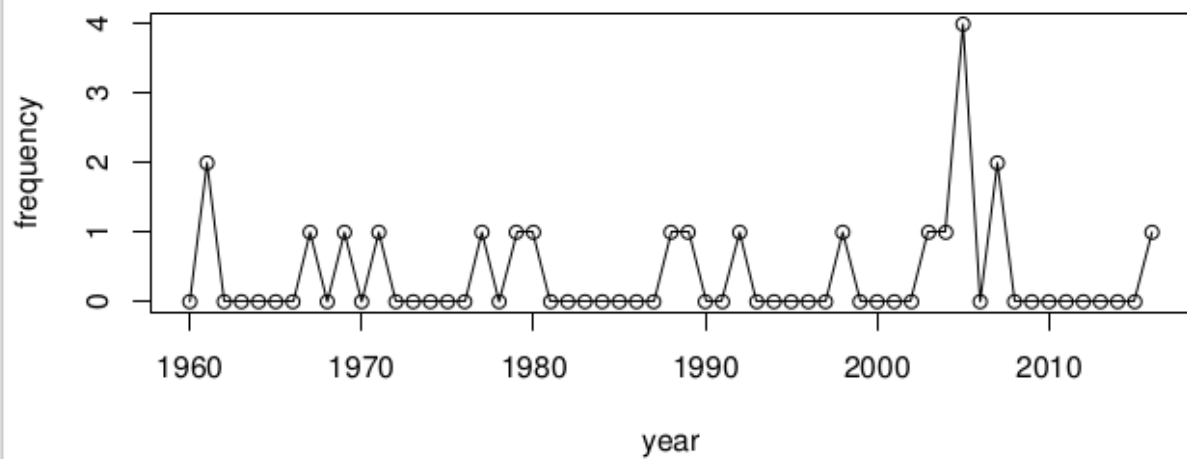


Avg emission over year (metric tons per capita

Category 5 By Year

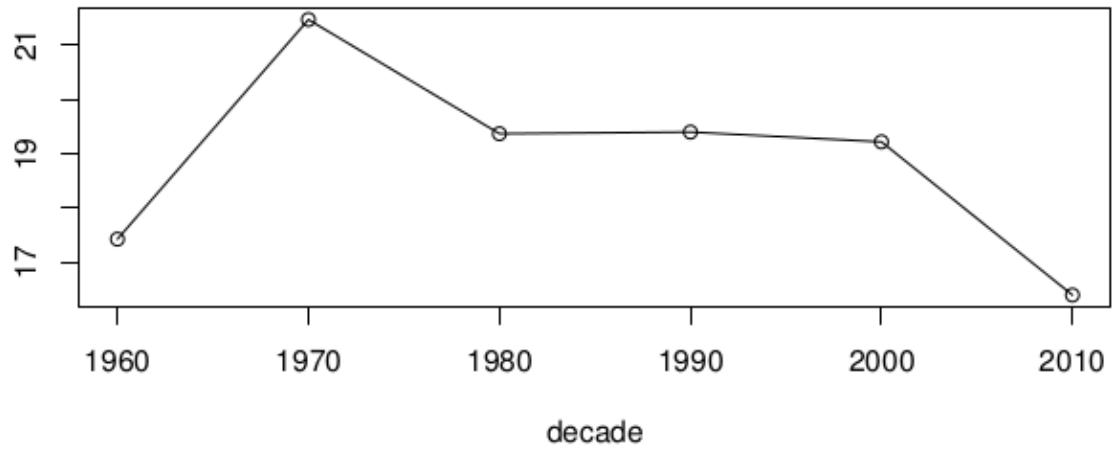


Category 5 By Year



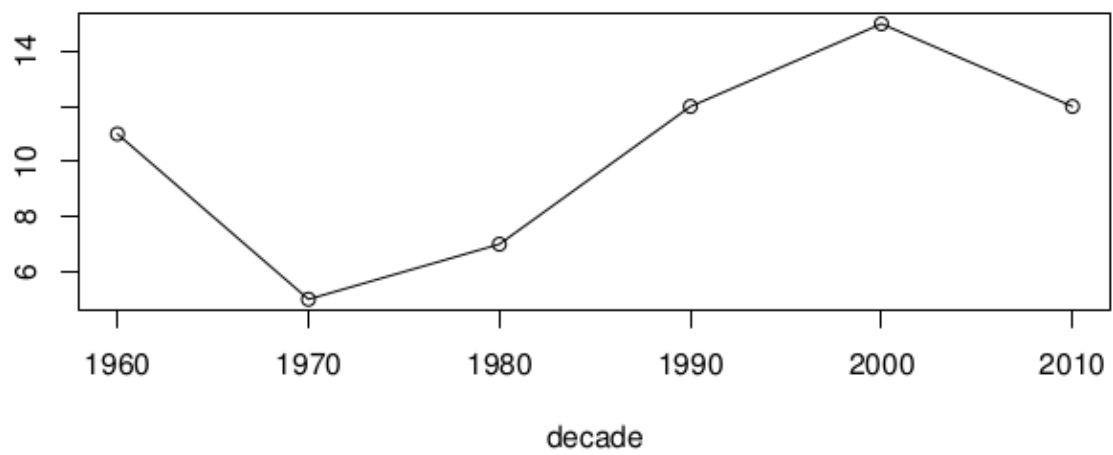
Avg emission over decade (metric tons per capi

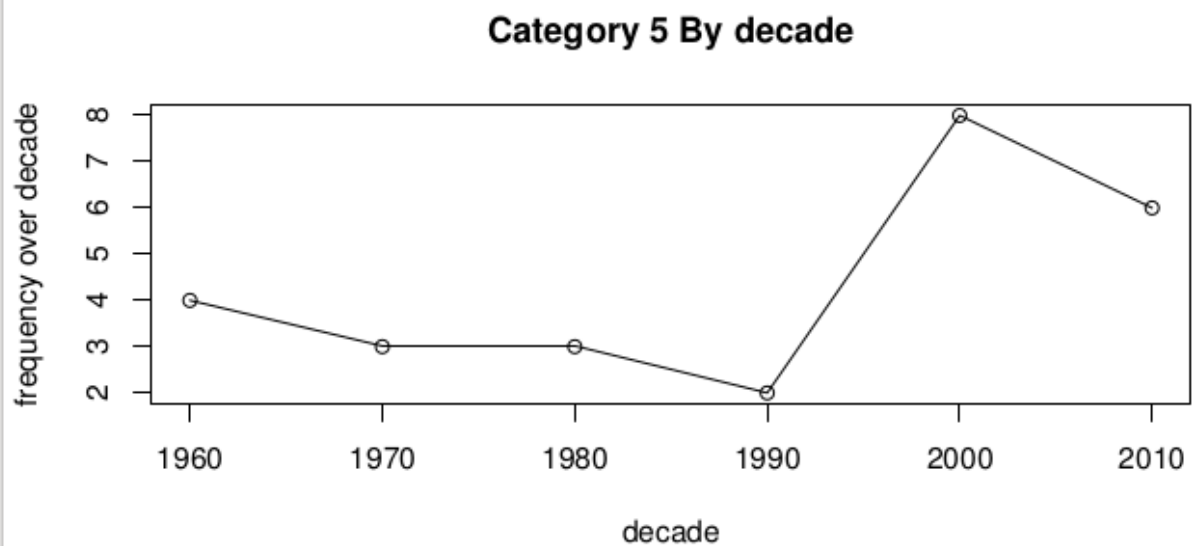
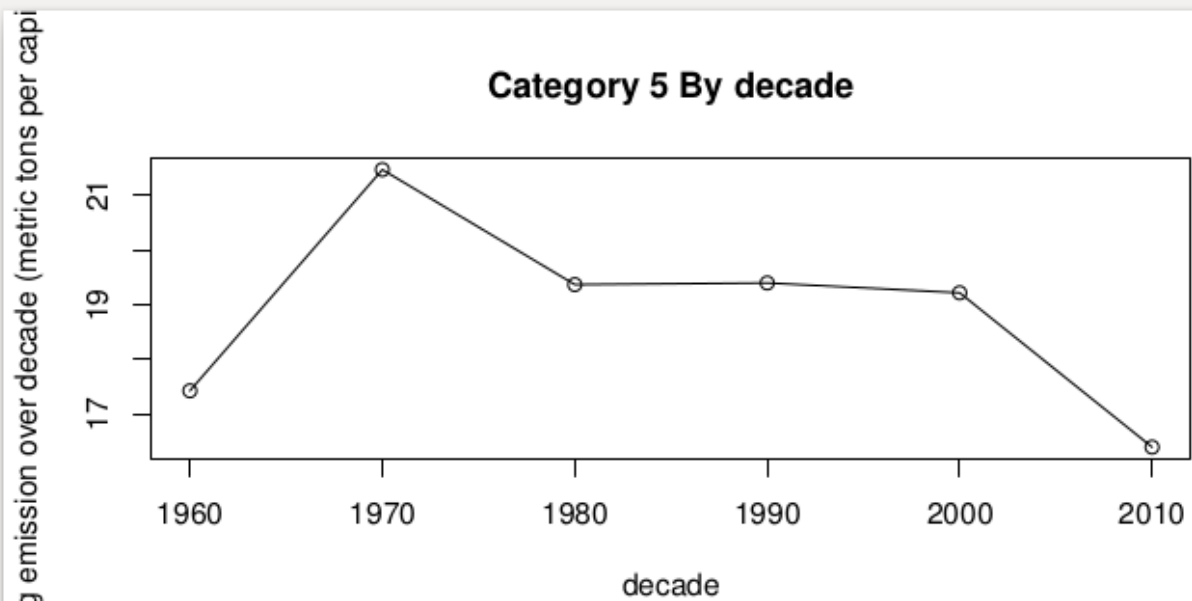
Category 4 By Decade



Category 4 By Decade

frequency over decade





References

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