Climate Change
~ its possible cause and effect ~

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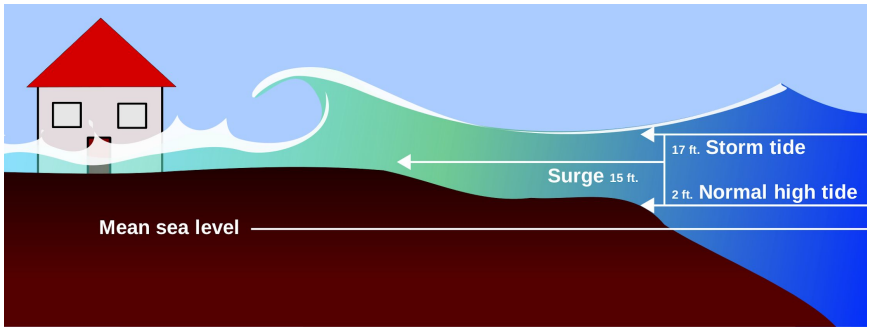
Introduction

- Global warming may…
  - increase the number and the strength of tropical cyclone
  - increase the sea level
- **In the construction of water dike, government may need to consider the effect of this climate change**

Mechanism of Storm Surge



Water height is surged by low air pressure and strong window

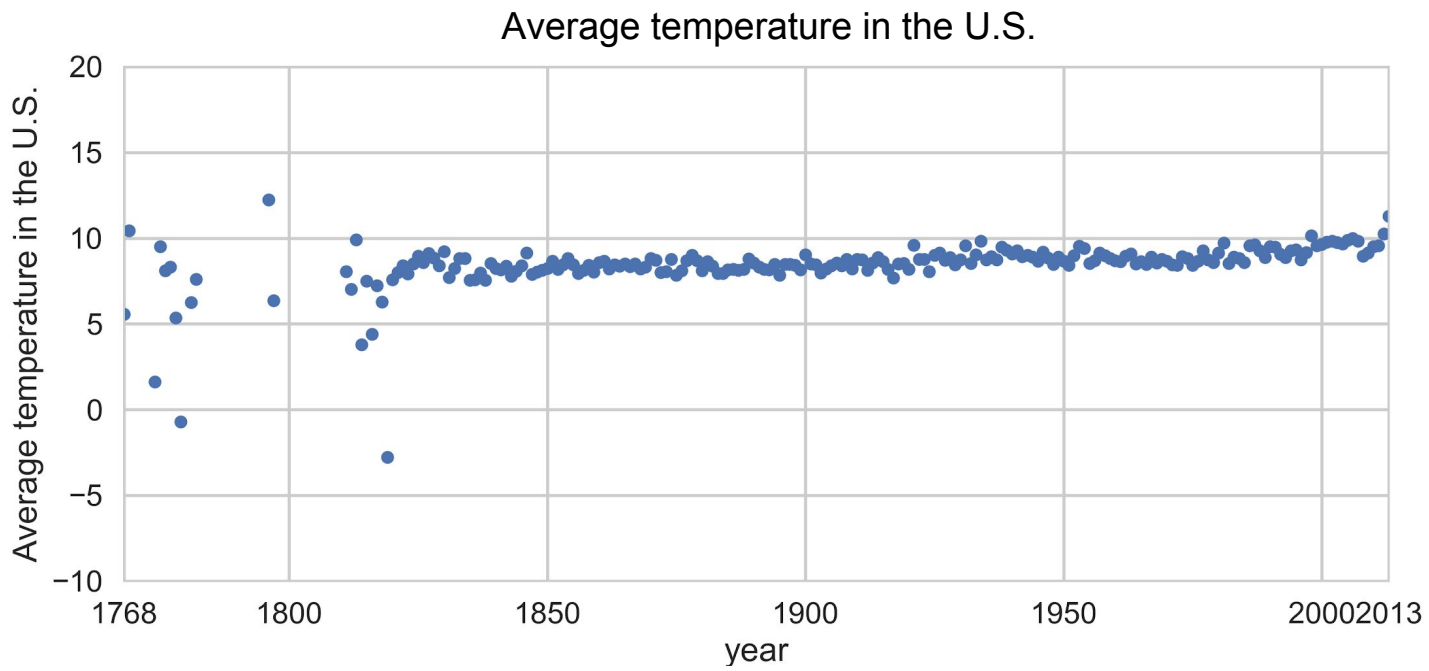
Damage by Storm Surge to Kasan Airport, Japan (Sep., 2018)

Research Questions

1. **Phenomenon -Climate Change-**
    a. How is the average temperature shifting in the past 200 years?
    b. How does the average temperature in the U.S. distribute over every 50 years? Does it different each other?
2. **Possible Effect**
    a. What is the correlation between the annual average temperature in the U.S. and the number of hurricanes or the max window's strength of hurricanes in the year?
3. **Possible Cause**
    a. What are the trends of carbon emission from electricity generation due to different fuels?
    b. How that correlates with USA's GDP? Is it getting more or less carbon efficient?

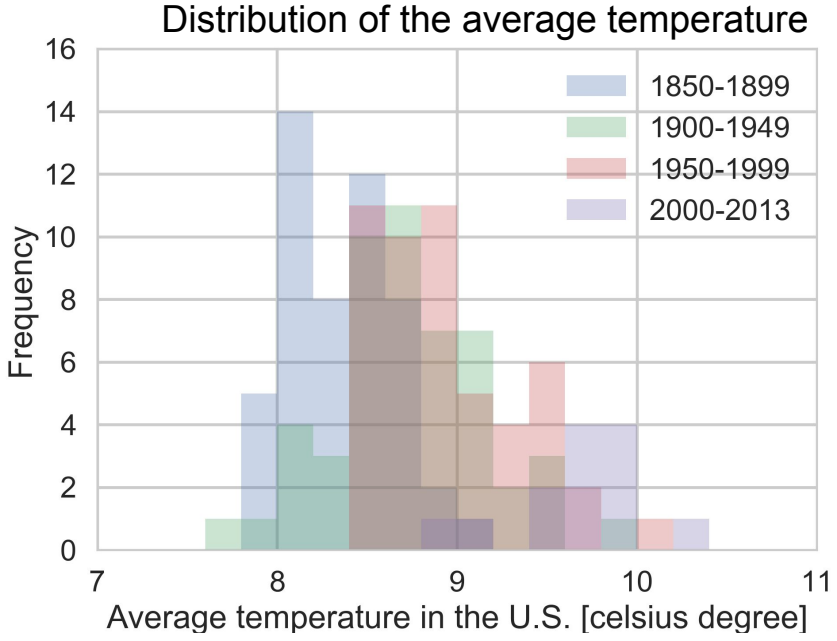
1-a How is the average temperature shifting in the past 200 years?

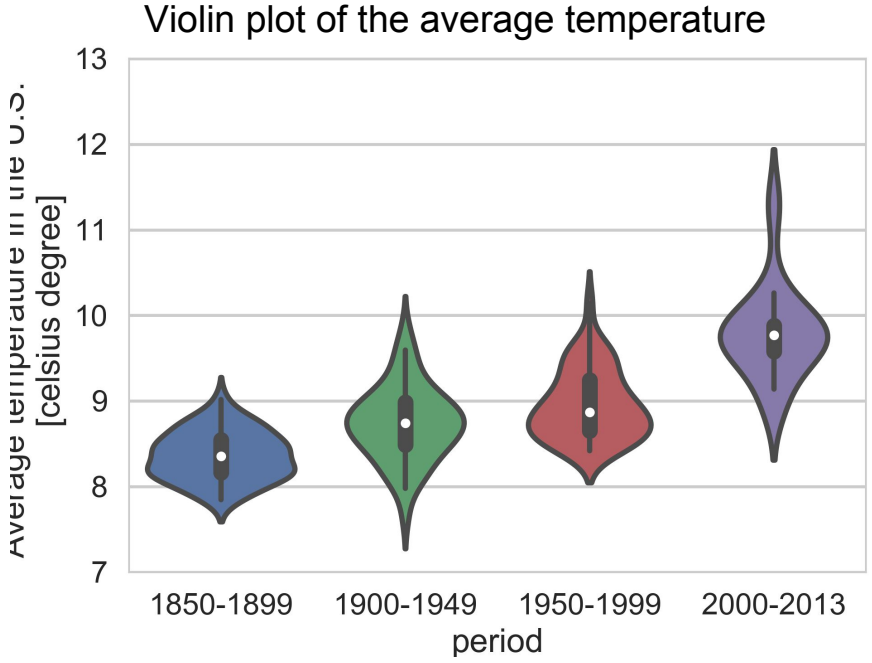
- Average temperature shows increasing trend intuitively
- Data before 1850 shows large variance (because of more inaccurate thermometer, inconsistent place of observatories)



1-b How does the average temperature in the U.S. distribute over every 50 years? Does it different each other?

- The average temperature in the every 50 years period shows normal distribution
- The median temperature of each period is increasing





1-b How does the average temperature in the U.S. distribute over every 50 years? Does it different each other?

- one -way ANOVA shows F-value of 53.19 (p-value = 6.62 ×10-24). At least one of the period shows statistically significant difference among the four periods.
- With Tukey-Kramer method, all of the combination of periods shows statistically significant difference
- High possibility of the increase of the average temperature was demonstrated by both intuitively and statistically

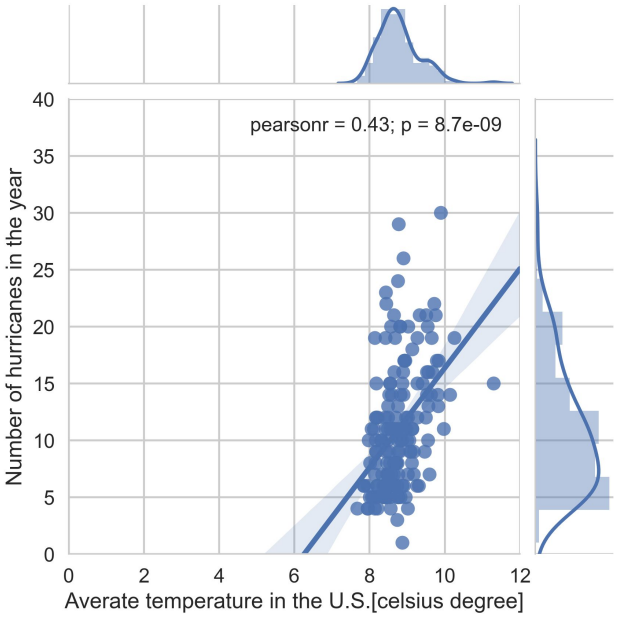
Result of Tukey-Kramer method

group1	group2	meandiff	lower	upper	reject
1850-1899	1900-1949	0.3798	0.1747	0.585	True
1850-1899	1950-1999	0.5957	0.3905	0.8008	True
1850-1899	2000-2013	1.4364	1.1262	1.7465	True
1900-1949	1950-1999	0.2158	0.0107	0.421	True
1900-1949	2000-2013	1.0565	0.7464	1.3667	True
1950-1999	2000-2013	0.8407	0.5306	1.1509	True

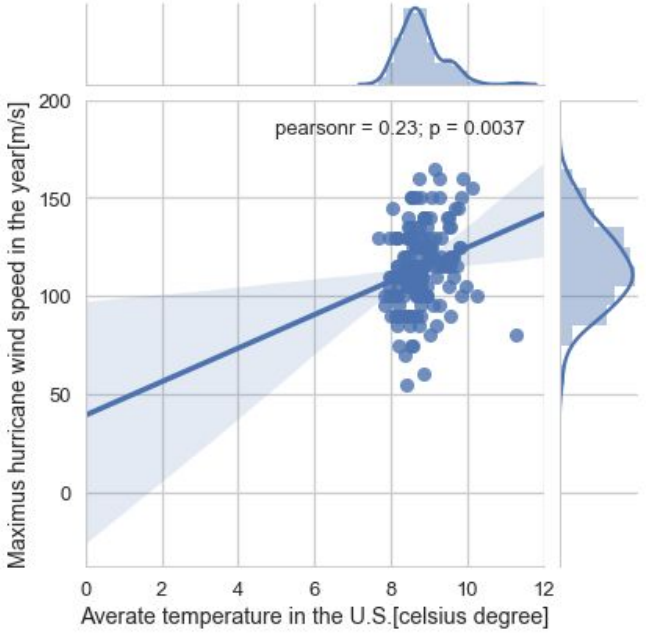
2-a Relationship between the average temperature and the number of hurricanes or strength of hurricanes

- The average temperature is correlated with the number of hurricanes and maximum hurricane wind (The number of hurricane shows stronger correlation)

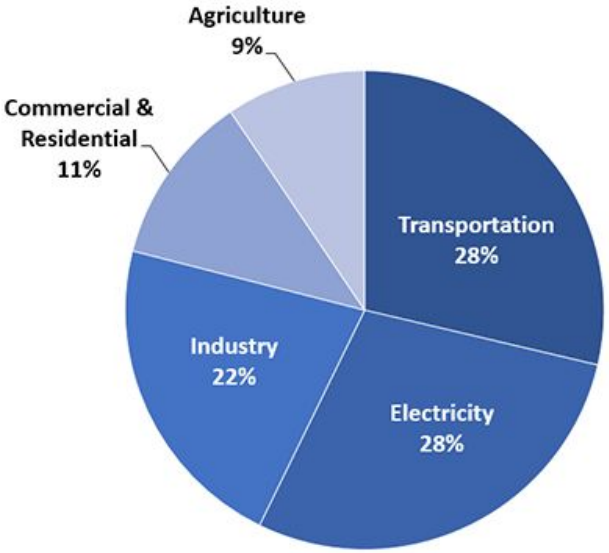
Number of hurricanes in each year

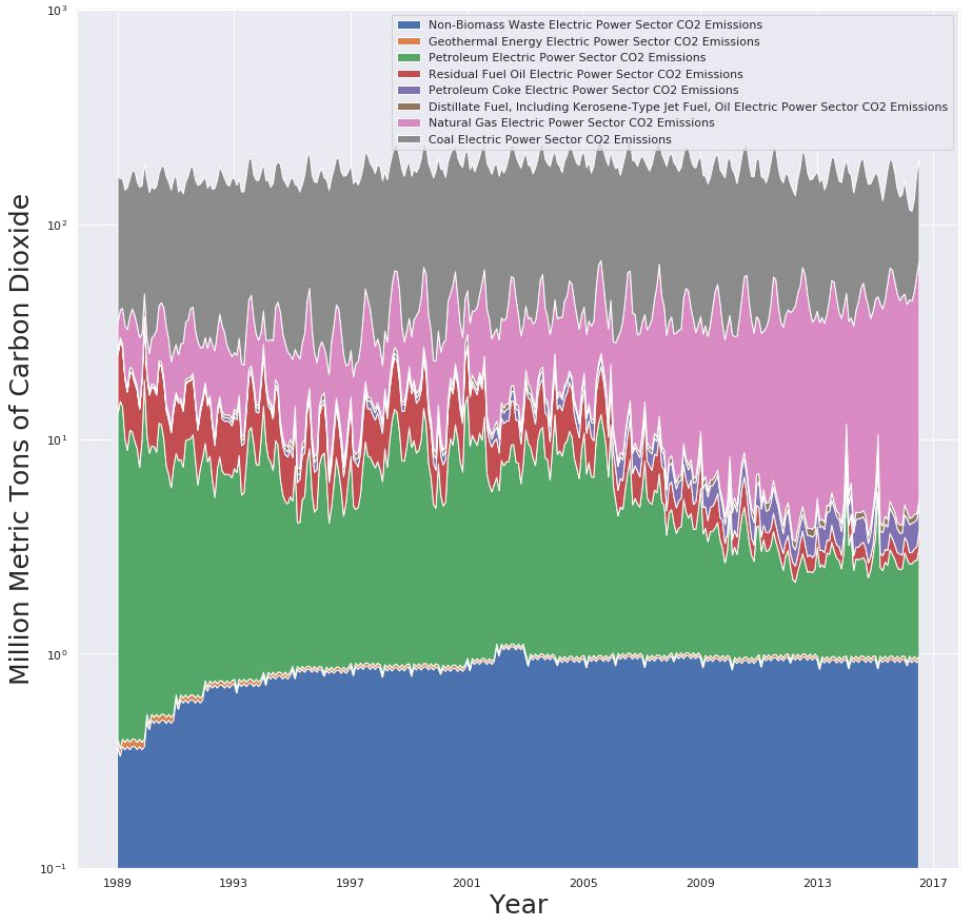


Maximum hurricane wind in each year

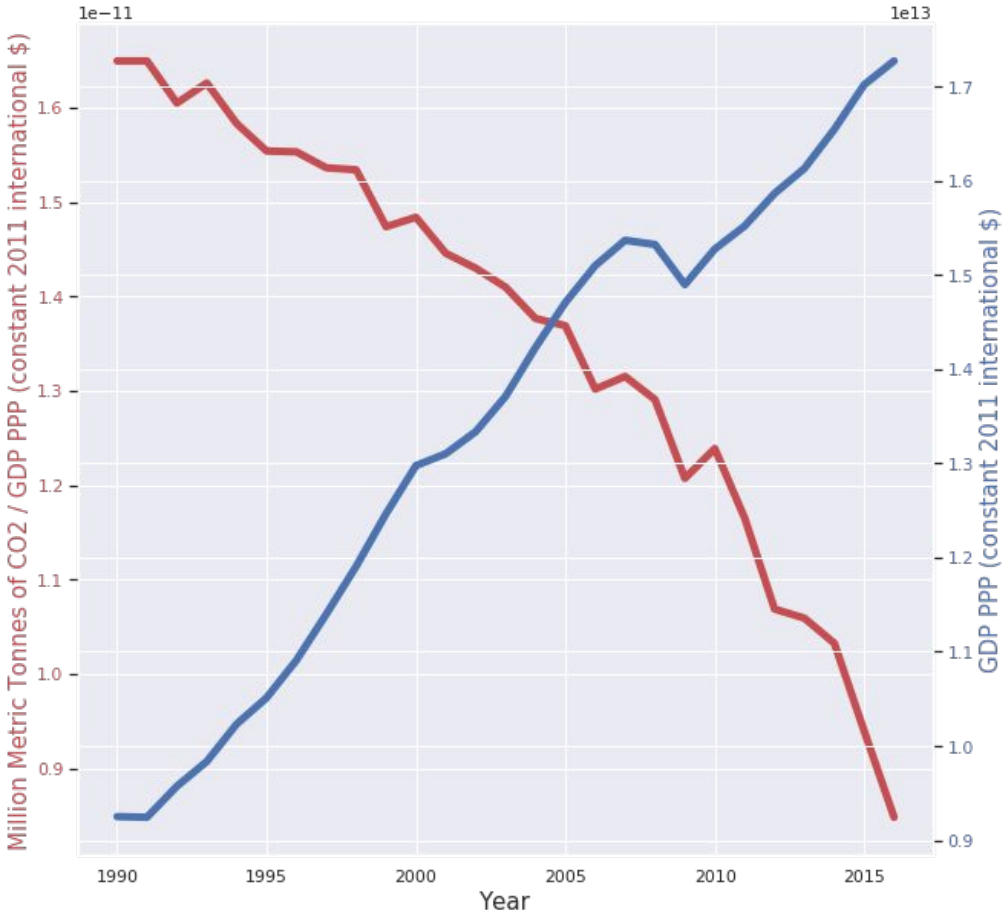


3-a What are the trends of carbon emission from electricity generation due to different fuels?





3-b How that trends with USA's GDP? Is the US getting more or less carbon efficient?



Conclusion

- High possibility of the increase of the average temperature was demonstrated by both intuitively and statistically
- The average temperature is correlated with the number of hurricanes and maximum hurricane wind
- The USA is producing as much carbon dioxide from electricity generation now as 20 years back. The dominant source of carbon is coal.
- It is becoming more carbon efficient when measured by the GDP PPP / Carbon emission from electricity generation. In fact, about twice as efficient. Increasing rate of improvement.