Climate Change Analysis

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# Introduction

In the past 4.5 billion years, Earth has gone through numerous climate changes that reshaped its surface and ecosystem, causing extinction and evolution itself. While the Sun is the biggest influence on our climate, the composition of Earth's atmospheric gasses defines how much of the Sun's energy will be trapped under the atmosphere. Ultimately the principles of thermodynamics while increasing the entropy, will govern the future of the Earth. Infinitesimal changes within a system in the present can cause changes within system in the future with a tremendous magnitude leaving the system incomparable to its primal state.

In this study, I will focus on a few questions related to current climate changes. For the research, I will be using the Data set published on Kaggle.com which contains data with temperature details in the period between 1750 and 2013:

1. Global Average Land Temperature by Country (GlobalLandTemperaturesByCountry.csv)
2. Global Average Land Temperature by state (GlobalLandTemperaturesByState.csv)
3. Global Land Temperatures by major cities (GlobalLandTemperaturesByMajorCity.csv)
4. Global Land Temperatures by all cities (GlobalLandTemperaturesByMajorCity.csv)

[Data Location:] (<https://www.kaggle.com/berkeleyearth/climate-change-earth-surface-temperature-data>)

Questions of Interest:

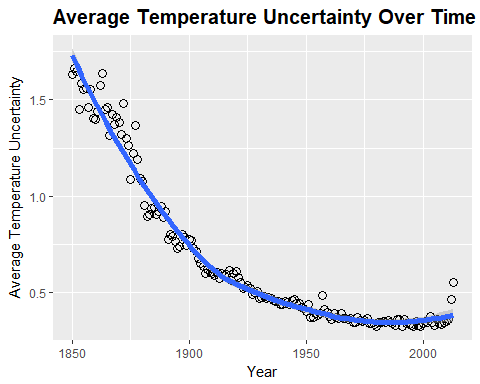
1. What is the measurement problem and uncertainty level within these data sets?
2. What is the difference between the land and ocean average temperatures over time?
3. How do temperature extremes relate to average temperature?
4. What is the temperature trend over all the states/countries in the world?
5. What are the top 10 coldest and hottest major cities in the world?
6. What are the locations of the coldest vs. hottest major cities?
7. How does the average temperature difference look on a global scale?
8. What is the temperature trend for a city of residence (Atlanta)?
9. What kind of climate can we expect for the next 5 years, 10 years, 50 years and 100 years based on Predictive Analysis?
10. Is there active global warming?

# Descriptive Analytics

## Temperature Uncertanity for Data used in Descriptive Analytics

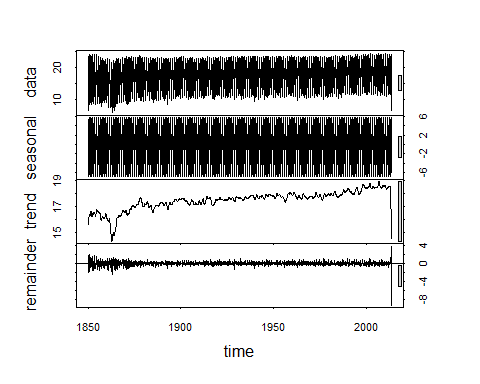
With given sets of data, we have a level of uncertainty due to imperfections in measurements and collection of the average temperature. Based on graph below we can see that between 1850 and 1975 we have a decline of uncertainty from 1.5% below 0.5%. The reliability of data stabilizes from 1975 with the exception to two outliers in 2013.

# loading data set to explore data uncertainty. Eliminating NA values, standardizing dates and creating data sets for analysis.   
  
TempByAllCities <- read\_csv("C:/GIT/R/Data\_Source/GlobalLandTemperaturesByCity.csv")  
# Eliminating NAs  
TempByAllCities <- na.omit(TempByAllCities)  
# Converting dt to correct dates  
TempByAllCities$dt <- as.Date(TempByAllCities$dt, "%Y-%m-%d")  
# Filtering data range  
TempByAllCities <- filter(TempByAllCities, dt>= "1849-12-31")  
# Extracting the month out of dt  
TempByAllCities$Month <- month(TempByAllCities$dt)  
# Converting Month number to Month Name  
TempByAllCities$Month <- month(TempByAllCities$Month, label = TRUE)  
# Extracting the year out of dt  
TempByAllCities$Year <- year(TempByAllCities$dt)  
# Converting Lat and Long to correct format  
TempByAllCities$LAT <- as.numeric(gsub("N|E|S|W", "",TempByAllCities$Latitude))\*ifelse(grepl("S",TempByAllCities$Latitude),-1,1)  
TempByAllCities$LONG <- as.numeric(gsub("N|E|S|W", "", TempByAllCities$Longitude))\*ifelse(grepl("W",TempByAllCities$Longitude),-1,1)  
AvgTempUncert <- TempByAllCities %>% group\_by(Year) %>% summarise(AvgTempUnc = mean(AverageTemperatureUncertainty))  
ggplot(AvgTempUncert,aes(x= Year,y= AvgTempUncert$AvgTempUnc))+  
 geom\_point(shape=1, size = 3)+ geom\_smooth(method="loess", size = 2)+ labs(title="Average Temperature Uncertainty Over Time", x="Year", y="Average Temperature Uncertainty") + theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold"))



## Exploring Seasons

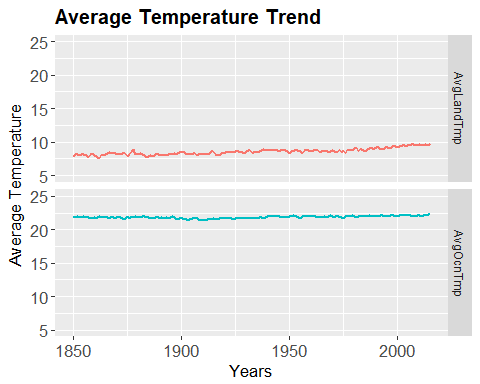
Using the temperature data set from every city, we are going to explore the seasonality trend for the years between 1850 and 2013. On the Seasonality graph below we can see the average temperature increase over the century and half.



## Analysis of Global Temperature (Land Vs Ocean)

ased on the Average Temperature Graph bellow, we can see that the average temperature of the land has been significantly increasing with a higher rate than the temperature of the ocean. Oceans are heating and cooling much faster than land due to the low density of the water. There are a few factors that could cause the average land temperature to increase with a higher rate than the ocean average temperature. With rapid deforestation, we reduce absorption of greenhouse gases that fuel global warming. Fewer forests will allow larger amounts of greenhouse gases to enter the atmosphere (~15% carbon) and trap the solar rays and heat up the surface that had once been protected by forest. Industrial effects within developed and developing countries plays a significant role where emission of greenhouse gasses (CO and CO2) directly influences speed and severity of the temperature in those regions and globally as well. The United States constitutes 5% of the world population and contributes 22% of the world’s carbon emission.

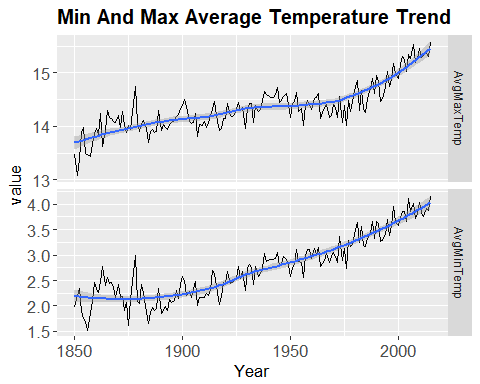
# Loading data set  
GlobalTemperatures <- read\_csv("C:/GIT/R/Data\_Source/GlobalTemperatures.csv")  
# Standardizing the date format  
GlobalTemperatures$dt = as.Date(GlobalTemperatures$dt, "%Y-%m-%d" )   
# Filtering data range  
GlobalTemperatures <- filter(GlobalTemperatures, dt>= "1849-12-31")  
# Extracting the month out of the dt column in to new Monthviw column  
GlobalTemperatures$Month <- month(GlobalTemperatures$dt)  
# Converting month number in to Month Name  
GlobalTemperatures$Month <- month(GlobalTemperatures$Month, label = TRUE)  
# Extracting the year out of the dt column in to new Year column  
GlobalTemperatures$Year <- year(GlobalTemperatures$dt)  
# Remove rows that contains NA  
GlobalTemperatures <- GlobalTemperatures[!is.na(GlobalTemperatures$LandAndOceanAverageTemperature) | !is.na(GlobalTemperatures$LandAverageTemperature),]  
# Calculate AverageOcean Temperature  
GlobalTemperatures$OceanAverageTemperature = as.numeric(GlobalTemperatures$LandAndOceanAverageTemperature) \* 2 - as.numeric(GlobalTemperatures$LandAverageTemperature)  
# Summerizing temperature on yearly level  
GlobalTemperaturesSummary <- GlobalTemperatures %>% group\_by(Year) %>% summarise(AvgLandTmp = mean(LandAverageTemperature), AvgOcnTmp = mean(OceanAverageTemperature))  
# Ploting Avgerage Ocean Temperature and Average Land temperature on timescale  
Plot\_ds <-melt(GlobalTemperaturesSummary, id ="Year")  
ggplot(data= Plot\_ds, aes(x=Year, y= value, colour = variable)) +  
 geom\_line(size = 1) + coord\_cartesian(ylim = c(5, 25)) + xlab("Years") + ylab("Average Temperature") +  
 theme(axis.title = element\_text(size = 13), axis.text = element\_text(size = 13)) +  
 ggtitle("Average Temperature Trend") +  
 theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold")) + facet\_grid(Plot\_ds$variable ~., scales = "free\_y") + theme(legend.position="none")



## Minimum and Maximum Average Temperature Trends

Analysis of temperature extremes over time require daily maximum and minimum temperature data from stations with records of sufficient length, quality, completeness, and temporal homogeneity. Homogeneity of the daily temperature record is a challenge due to stations experiencing variation in degrees of change over time for particular locations, instrumentation, observing practices, and sitting conditions. On the Min and Max Average Temperature Trend graph below, we can see the amplitudes of change for these extremes. It is clear that both temperature extremes across a century and a half are slightly increasing. the correlation between these extremes is ~90%.

# Extracting min and max values   
GlobalTemperaturesMinMax <- GlobalTemperatures %>% group\_by(Year) %>% summarise(AvgMaxTemp = mean(as.numeric(LandMaxTemperature)), AvgMinTemp = mean(as.numeric(LandMinTemperature)))  
# Preparing variable for plot using melt function creating identifier and measured variable.  
Plot\_minMAx <-melt(GlobalTemperaturesMinMax, id = "Year")  
# Plotting min and max temperature trend.   
ggplot(data = Plot\_minMAx, aes(Year, value, variable)) + geom\_line(size = .5) + geom\_smooth(size = 1) + facet\_grid(Plot\_minMAx$variable ~ ., scales = "free\_y") + theme(axis.title = element\_text(size = 13), axis.text = element\_text(size = 13)) +  
 ggtitle("Min And Max Average Temperature Trend") +  
 theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold"))



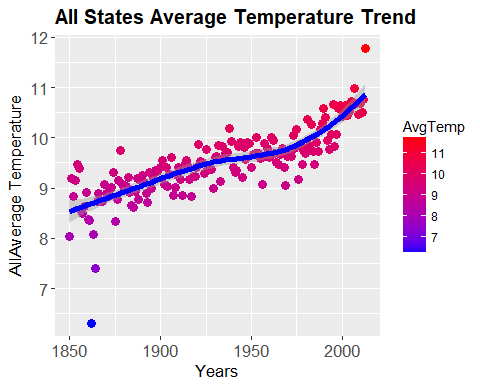
# Runing the coorelation between max and min temperature  
cor(GlobalTemperaturesMinMax$AvgMaxTemp, GlobalTemperaturesMinMax$AvgMinTemp)

## [1] 0.8980115

## Average Temperature Difference Between 1850 and 2013

The All State Average Temperature trend bellow illustrates the change in global surface temperature relative to 1850-2013 average temperatures. Thirteen of the warmest years in the 163-year record all have occurred since 2000. With a focus on the period between 1975 and 2013 the data shows nearly a 1-degree Celsius increase with respect to data uncertainty.

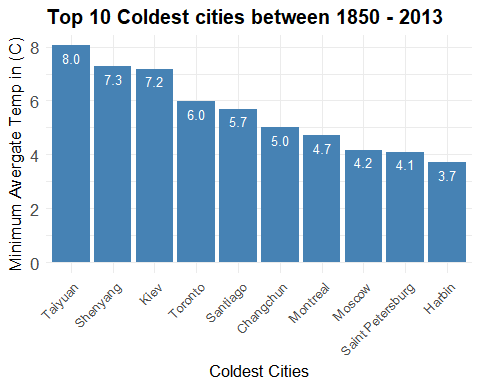
# Loading data set  
GlobalLandTemperaturesByState <- read\_csv("C:/GIT/R/Data\_Source/GlobalLandTemperaturesByState.csv")  
# Formating dates  
GlobalLandTemperaturesByState$dt <- as.Date(GlobalLandTemperaturesByState$dt, "%Y-%m-%d")  
# Filtering data range  
GlobalLandTemperaturesByState <- filter(GlobalLandTemperaturesByState, dt>= "1849-12-31")  
# Removing NAs  
GlobalLandTemperaturesByState = na.omit(GlobalLandTemperaturesByState)  
# Extracting Month from dt column in to new Month column  
GlobalLandTemperaturesByState$Month <- month(GlobalLandTemperaturesByState$dt)  
GlobalLandTemperaturesByState$Year <- year(GlobalLandTemperaturesByState$dt)  
# Extract avg temperature by year  
GlobalTempSummary <- GlobalLandTemperaturesByState %>% group\_by(Year) %>% summarise(AvgTemp = mean(AverageTemperature))  
# Creating plot  
ggplot(data = GlobalTempSummary, aes(x = Year, y = AvgTemp, colour = AvgTemp)) + geom\_point(shape=16, size =3) + geom\_smooth(method = 'loess', color = 'blue', size = 2) + xlab("Years") + ylab("AllAverage Temperature") + theme(axis.title = element\_text(size = 13), axis.text = element\_text(size = 13)) + ggtitle("All States Average Temperature Trend") + theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold")) + aes(Colour = AvgTemp) + scale\_color\_gradient(low = "blue", high = "red")



## Top 10 Coldest Major Cities between 1850 - 2013

With the given average temperature for every major city, the bar chart below has the top 10 coldest cities in the world with descending rank.

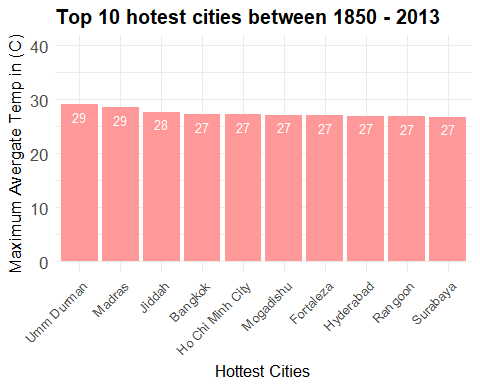
# Loading data set  
GlTempCity <- read\_csv("C:/GIT/R/Data\_Source/GlobalLandTemperaturesByMajorCity.csv")  
#Formating Data Range  
GlTempCity$dt <- as.Date(GlTempCity$dt, "%Y-%m-%d")  
# Filtering data range  
GlTempCity <- filter(GlTempCity, dt>= "1849-12-31")  
# Filtering out NAs  
GlTempCity = na.omit(GlTempCity)  
# Extracting the month out of dt  
GlTempCity$Month <- month(GlTempCity$dt)  
# Converting Month number to Month Name  
GlTempCity$Month <- month(GlTempCity$Month, label = TRUE)  
# Extracting the year out of dt  
GlTempCity$Year <- year(GlTempCity$dt)  
# Grouping by City with avg. temperature on average  
GlTempSum <- GlTempCity %>% group\_by(City, Longitude, Latitude) %>% summarise(AvgTemp = mean(AverageTemperature))  
# Extracting top 10 hotest city  
Top10Hotest <- head(arrange(GlTempSum, desc(AvgTemp)), n= 10)  
# Extracting top 10 coldest city on average  
Top10Coldest <- head(arrange(GlTempSum, AvgTemp), n = 10)  
# Plotting the the top 10 coldest cities  
ggplot(data = Top10Coldest, aes(x = reorder(City, - AvgTemp), y = AvgTemp)) + geom\_bar(stat = "identity", position = "dodge", fill="steelblue") + geom\_text(aes(label=format(Top10Coldest$AvgTemp, digits = 2)), vjust=1.6, color="white", size=3.5) + theme\_minimal() + xlab("Coldest Cities") + ylab("Minimum Avergate Temp in (C)") + theme(axis.title = element\_text(size = 13), axis.text = element\_text(size = 13)) + ggtitle("Top 10 Coldest cities between 1850 - 2013") + theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold")) + theme(axis.text.x = element\_text(size = 10, angle = 45, hjust = 1, vjust = 1))



## Top 10 Hottest Major Cities between 1850 - 2013

While we have a drastic difference within the top 10 coldest major cities in the world, the top 10 hottest cities are very similar in comparison in their average temperature across a century and half.

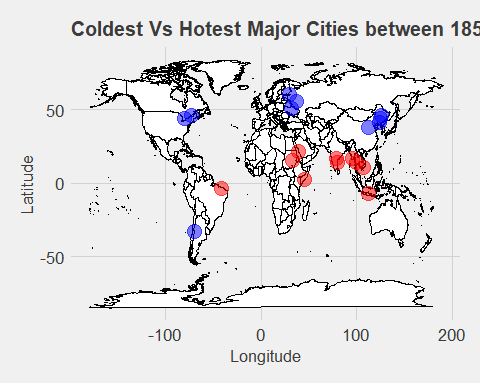
# Plotting the top 10 hottest cities  
ggplot(data = Top10Hotest, aes(x = reorder(City, - AvgTemp), y = AvgTemp)) + geom\_bar(stat = "identity", position = "dodge", fill="#FF9999") + geom\_text(aes(label=format(Top10Hotest$AvgTemp, digits = 2)), vjust=1.6, color="white", size=3.5) + theme\_minimal() + xlab("Hottest Cities") + ylab("Maximum Avergate Temp in (C)") + theme(axis.title = element\_text(size = 13), axis.text = element\_text(size = 13)) + ggtitle("Top 10 hotest cities between 1850 - 2013") + theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold")) + theme(axis.text.x = element\_text(size = 10, angle = 45, hjust = 1, vjust = 1)) + coord\_cartesian(ylim = c(0, 40))



## Coldest vs. Hottest Cities on WorldMap

Using longitude and latitude information for the given data, we can plot the location of the top 10 coldest and top 10 hottest cities on the world map. It is interesting to see that all of the coldest cities, with the exception of Santiago, are scattered in the Northern Hemisphere. The top 10 hottest cities are scattered around the Equator.

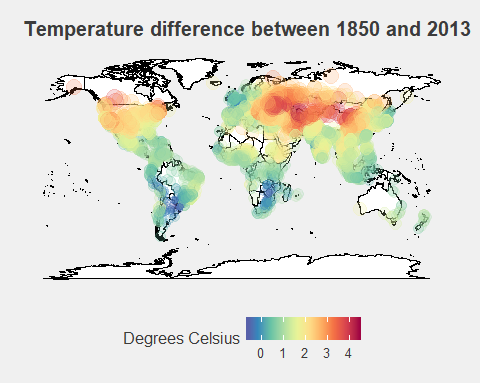
# Converting Longitude and latitude in correct format in Top10coldest dataset  
Top10Coldest$LAT <- as.numeric(gsub("N|E|S|W", "",Top10Coldest$Latitude))\*ifelse(grepl("S",Top10Coldest$Latitude),-1,1)  
Top10Coldest$LONG <- as.numeric(gsub("N|E|S|W", "", Top10Coldest$Longitude))\*ifelse(grepl("W",Top10Coldest$Longitude),-1,1)  
# Converting Longitude and latitude in correct format in Top10Hotest dataset  
Top10Hotest$LAT <- as.numeric(gsub("N|E|S|W", "",Top10Hotest$Latitude))\*ifelse(grepl("S",Top10Hotest$Latitude),-1,1)  
Top10Hotest$LONG <- as.numeric(gsub("N|E|S|W", "", Top10Hotest$Longitude))\*ifelse(grepl("W",Top10Hotest$Longitude),-1,1)  
# Plottinig the coldest and hottest cities on world map  
mapWorld <- borders("world", colour="black", fill="white") # create a layer of borders  
mp <- ggplot() + mapWorld  
mp <- mp+ geom\_point(aes(x=Top10Coldest$LONG, y=Top10Coldest$LAT) ,color="blue", size=5, alpha = .5) + ggtitle('Coldest Vs Hotest Major Cities between 1850 and 2013') + theme\_fivethirtyeight() + xlab("Longitude") + ylab("Latitude") + theme(axis.title = element\_text(size = 13), axis.text = element\_text(size = 13)) + theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold"))  
mp2 <- ggplot() + mapWorld  
mp2 <- mp+ geom\_point(aes(x=Top10Hotest$LONG, y=Top10Hotest$LAT) ,color="red", size=5, alpha =.5)   
mp2



## Average Temperature by all Cities

On World Map with average temperature changes, we can see that the most significant temperature increase is measured in develoeped countries. These countries to be the ones who produce most of the greenhouse gasses.

# Grouping the dataset by Country and City  
TempByAllCitiesSum <- TempByAllCities %>% group\_by(Country, City) %>% select(AverageTemperature, City ,LAT, LONG, Country) %>% summarise(avgTemp\_start = mean(AverageTemperature), long = mean(LONG), lat = mean(LAT))  
# Focusing on year 2013  
Year2013 <- TempByAllCities %>% filter(Year ==2013)  
Year2013 <- Year2013 %>% group\_by(Country,City) %>% select(AverageTemperature,City) %>% summarise(avgTemp\_end = mean(AverageTemperature))  
# Getting the final dataset  
finalds <- merge(TempByAllCitiesSum,Year2013, by=c('Country','City'))  
# Ploting the avg. temp difference on map  
worldMap <- fortify(map\_data("world"), region = "region")  
m <- ggplot() + geom\_map(data = worldMap, map = worldMap,aes(x = long, y = lat, map\_id = region, group = group),fill = "white", color = "black", size = 0.1)  
m + geom\_point(data= finalds,aes(x=long, y=lat, size=avgTemp\_end - avgTemp\_start,color=avgTemp\_end - avgTemp\_start),alpha=.2) + theme\_fivethirtyeight() + ggtitle('Temperature difference between 1850 and 2013') + theme(axis.text = element\_blank(), panel.grid.major = element\_blank(), panel.grid.minor = element\_blank()) + labs(size = '') + scale\_color\_gradientn(name='Degrees Celsius',colors=rev(brewer.pal(10,'Spectral'))) + scale\_size(guide = 'none') + theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold"))



## Green House Gasses\*\*

**Carbon Dioxide (CO2)**

Carbon Dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon Dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.

**Methane (CH4)**

Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

**Nitrous Oxide (N2O)**

Nitrous Oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.

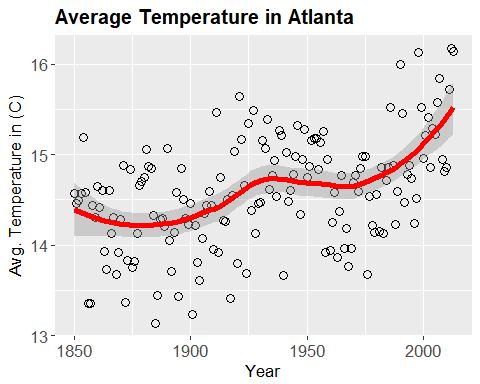
**Fluorinated Gases**

Hydrofluorocarbons, Perfluorocarbons, Sulfur Hexafluoride, and Nitrogen Trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone-depleting substances (e.g., chlorofluorocarbons, hydrochlorofluorocarbons, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").

## Average Temperature In Atlanta

Since this is a city of my residence I am going to explore the trend of Average temperature between 1850 and 2013 in Atlanta (Georgia).

# Extracting data for Atlanta and ploting on scatter plot   
ATLTemp <- filter(TempByAllCities, City == "Atlanta")  
ATLTempSum <- ATLTemp %>% group\_by(Year) %>% summarise(AvgTemp = mean(AverageTemperature))  
ggplot(ATLTempSum, aes(x=Year, y=AvgTemp)) + geom\_point(shape=1, size = 3) + geom\_smooth(method="loess", color = 'red', size = 2) + labs(title="Average Temperature in Atlanta ", x="Year", y="Avg. Temperature in (C)") +theme(axis.title = element\_text(size = 13), axis.text = element\_text(size = 13)) + theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold"))



# Predictive Analytics

Machine learning using algorithms to predict future temperature levels.

## Prediction for next 100 years

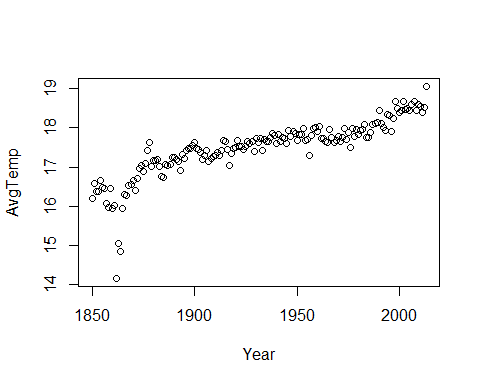
# Getting Avg Temp for every city per year  
NewYearsSet <- read\_csv("C:/GIT/R/Climate\_Change/NewYearsSet.csv")  
AllCityTempSum <- TempByAllCities %>% group\_by(Year) %>% summarise(AvgTemp = mean(AverageTemperature))  
AllCt.Tmp.Year <- subset(AllCityTempSum, select = c(Year, AvgTemp))  
# Exmploring the data structure  
summary(AllCt.Tmp.Year)

## Year AvgTemp   
## Min. :1850 Min. :14.15   
## 1st Qu.:1891 1st Qu.:17.19   
## Median :1932 Median :17.64   
## Mean :1932 Mean :17.48   
## 3rd Qu.:1972 3rd Qu.:17.88   
## Max. :2013 Max. :19.06

# Exploring cooralation between time and average temperature  
cor(AllCt.Tmp.Year, use="pairwise")

## Year AvgTemp  
## Year 1.0000000 0.8626077  
## AvgTemp 0.8626077 1.0000000

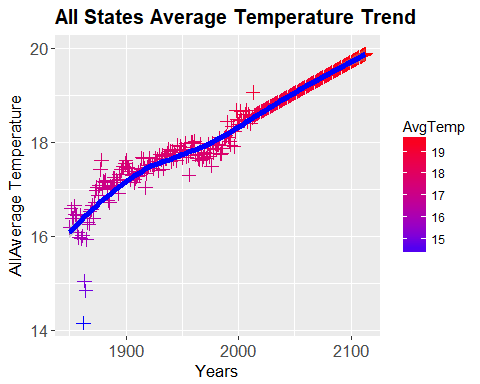
# plotting the trend  
plot(AllCt.Tmp.Year)



# Leaner Regression on all cities over century and half  
Mod.AllCityTemp <- lm(AvgTemp ~ Year, data = AllCt.Tmp.Year)  
# Exporing the results  
summary(Mod.AllCityTemp)

##   
## Call:  
## lm(formula = AvgTemp ~ Year, data = AllCt.Tmp.Year)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -2.40933 -0.12910 0.05232 0.19319 0.84513   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) -8.0814855 1.1782723 -6.859 1.39e-10 \*\*\*  
## Year 0.0132358 0.0006098 21.703 < 2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.3697 on 162 degrees of freedom  
## Multiple R-squared: 0.7441, Adjusted R-squared: 0.7425   
## F-statistic: 471 on 1 and 162 DF, p-value: < 2.2e-16

# Runing the prediction  
prediction <- predict(Mod.AllCityTemp, NewYearsSet, interval = "predict")  
# Observing the prediction  
View(prediction)  
# Introducing new set of years for forecasting  
NewYearsSet$AvgTemp <- prediction[,1]  
# Adding the values  
PredictedPlot <-bind\_rows(AllCityTempSum,NewYearsSet)  
# plotting the linear regression with prediction  
ggplot(data = PredictedPlot, aes(x = Year, y = AvgTemp, colour = AvgTemp)) + geom\_point(shape=3, size =3) + geom\_smooth(method = 'loess', color = 'blue', size = 2) + xlab("Years") + ylab("AllAverage Temperature") + theme(axis.title = element\_text(size = 13), axis.text = element\_text(size = 13)) + ggtitle("All States Average Temperature Trend") + theme(plot.title = element\_text(size = 15, lineheight=.8, face="bold")) + aes(Colour = AvgTemp) + scale\_color\_gradient(low = "blue", high = "red")



# NASA studdies and evidence for Rapid Climate Change\*\*\*

**Rise of the Sea Level**

In past centruy global sea level rose ~ 8 inches. This rate nearly dobuled in last two decades.

**Rise of the Ocean Temperature**

The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.302 degrees Fahrenheit since 1969.

**Shrinking of Ice Sheets**

The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost 150 to 250 cubic kilometers (36 to 60 cubic miles) of ice per year between 2002 and 2006, while Antarctica lost about 152 cubic kilometers (36 cubic miles) of ice between 2002 and 2005.

**Glacial Retreat**

Glaciers are retreating almost everywhere around the world — including in the Alps, Himalayas, Andes, Rockies, Alaska and Africa.

**Ocean Acidification**

Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 11,12. This increase is the result of humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the oceans. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year. 13,14

**Increase of the Global Temperature**

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth’s orbit that change the amount of solar energy our planet receives.

# Conclusion

Based on conducted analysis, we can see that average temperature trend has highest growth in the past 3 decades. Since this research was not based on analysis of level of Green Gasses emition, I am unable to establish ratio of human influence on global warming versus natural event.  
While every event in the system in naturaly-logical cosenquence of the even that prior, as a civilization "Type 0" we might not be able to influnece Sun`s radiation spectrum but we can adjust our own behaviour.

# References

\*\* [EPA:] (<https://www.epa.gov/ghgemissions/overview-greenhouse-gases>)

\*\*\*[NASA:] (<https://climate.nasa.gov/evidence/>)