Module 2, Day 1

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MLDS
MACHINE LEARNING
FOR DATA SCIENCE

Who Am I?

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What We've Learned in Module 1

- Anaconda Package Manager
- Install and run code on Jupyter
- Version Controlling Concept
- Git
- GitHub and GitHub Desktop

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What We've Learned in Module 1

- Statistics
- Linear Algebra
- Optimization
- Bayes Rule
- Maximum Likelihood, Gradient Descent, ...

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What We've Learned in Module 1

- Python Basics (Syntax, Arrays, Loops, Functions and etc)
- Numpy
- Matplotlib

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Workshop Materials

GitHub: **UTMMLDS**

https://github.com/utmmlds

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https://youtu.be/14VYnFhBKcY

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The E[DA]

Exploratory Data Analysis

Edward Tufte (2006). *Beautiful Evidence*, Graphics Press LLC. www.edwardtufte.com

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Principles of Analytic Graphics

- **Principle 1**: Show comparisons
  - Evidence for a hypothesis is always ***relative*** to another competing hypothesis.
  - Always ask "Compared to What?"

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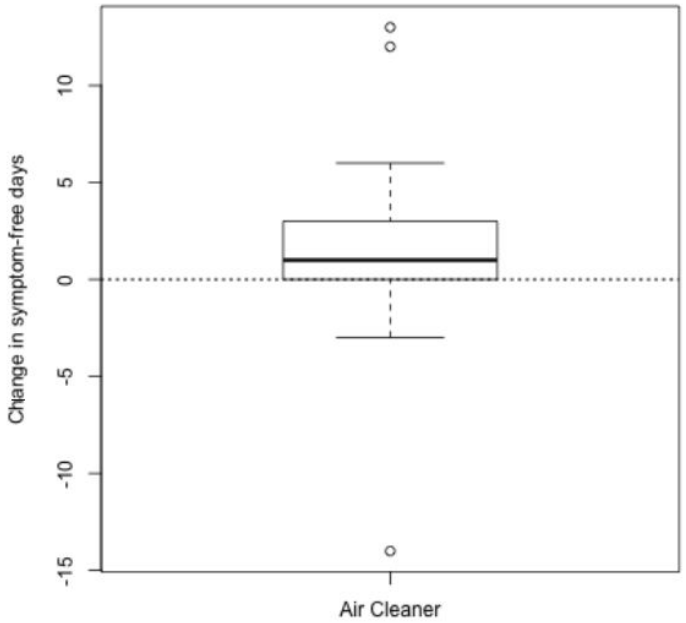
Show Comparisons



A boxplot which looks at the effect of an air cleaner on the asthma symptoms of children.

An air cleaner was introduced into a child's home, to reduce indoor air pollution levels.

Positive outcome! median increase was about one symptom-free day over 2 weeks.

Compared to what?

Reference: Butz AM, *et al.*, *JAMA Pediatrics*, 2011.

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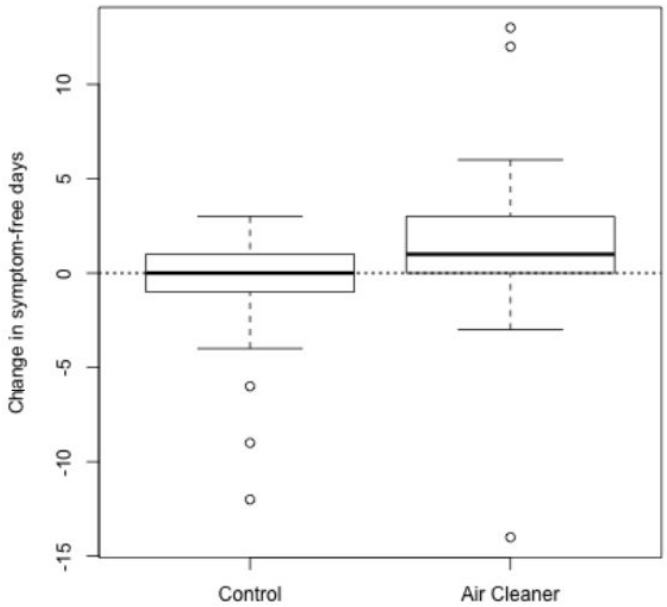
Show Comparisons



This was a randomized control trial that looked at installing an air cleaner in a child's home.

So in the control homes, the average change in the symptom free case was about 0.

Well relative to doing nothing, the air cleaner is actually a little bit better at showing an improvement in the child's symptoms.

Reference: Butz AM, *et al.*, *JAMA Pediatrics*, 2011.

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Principles of Analytic Graphics

- **Principle 1**: Show comparisons
  - Evidence for a hypothesis is always ***relative*** to another competing hypothesis.
  - Always ask "Compared to What?"
- **Principle 2**: Show causality, mechanism, explanation, systematic structure
  - What is your causal framework for thinking about a question?

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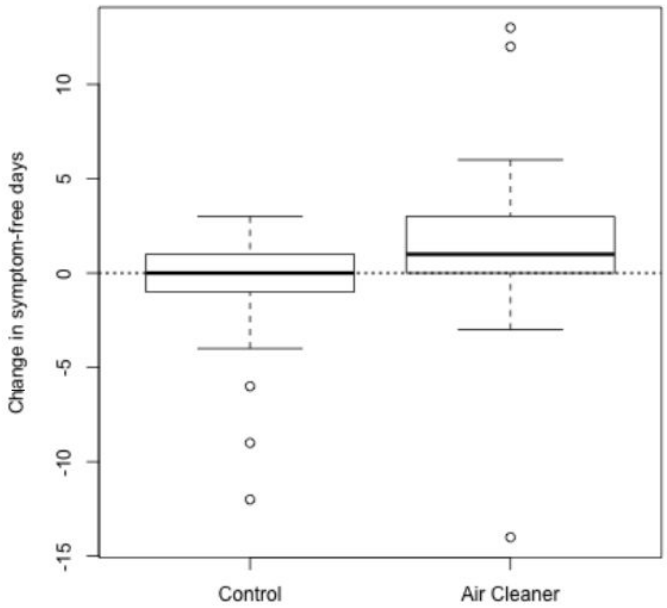
Show causality, mechanism



We saw that if you install an air cleaner in a child's home, that on average, they're going to experience a one symptom-free day increase, so a better outcome in their asthma symptoms.

Why is it that installing an air cleaner in a child's home, improves their symptoms?

Reference: Butz AM, *et al.*, *JAMA Pediatrics*, 2011.

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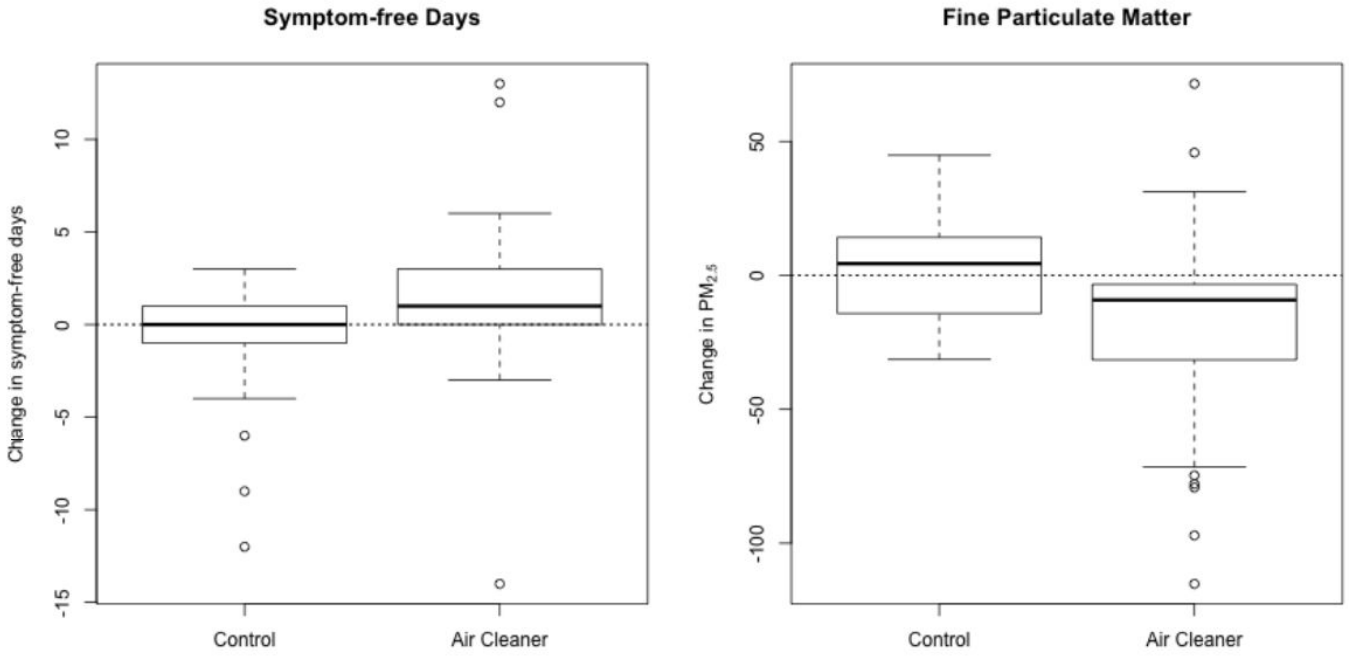
Show causality, mechanism



Reference: Butz AM, *et al.*, *JAMA Pediatrics*, 2011.

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- **Principle 3**: Show multivariate data
  - Multivariate = more than 2 variables
  - The real world is multivariate
  - Need to "escape flatland"

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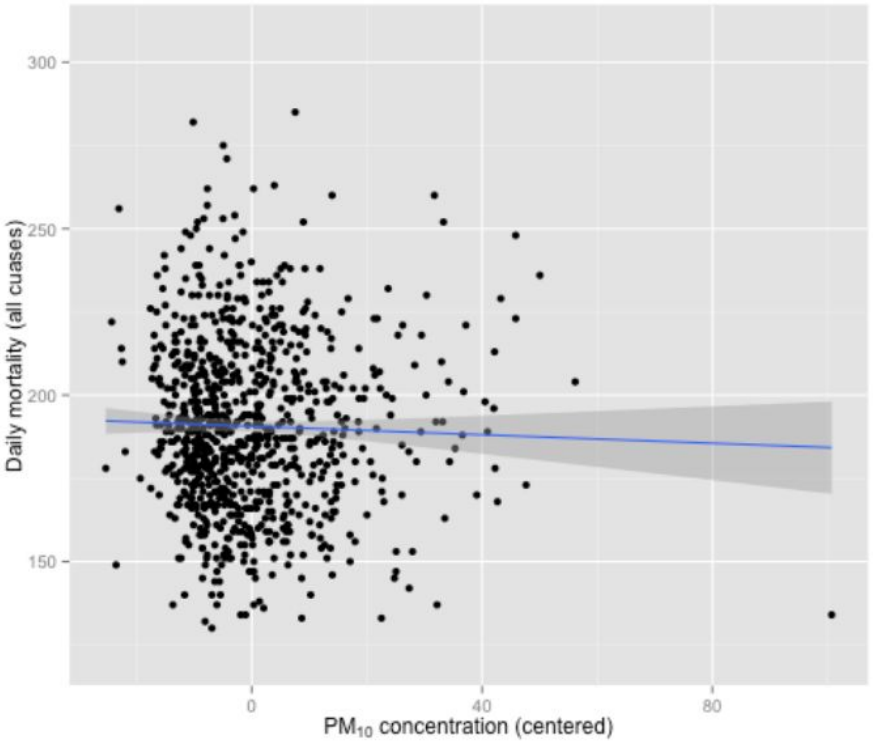
Show Multivariate Data



The X axis we have, particulate matter less than 10 microns in aerodynamic diameter, the concentrations of those, from day to day.
Every circle → a daily concentration

The y axis, we have the daily mortality in New York City. This is for the time period 1987 to, 2000.

How does this relationship change across different seasons?

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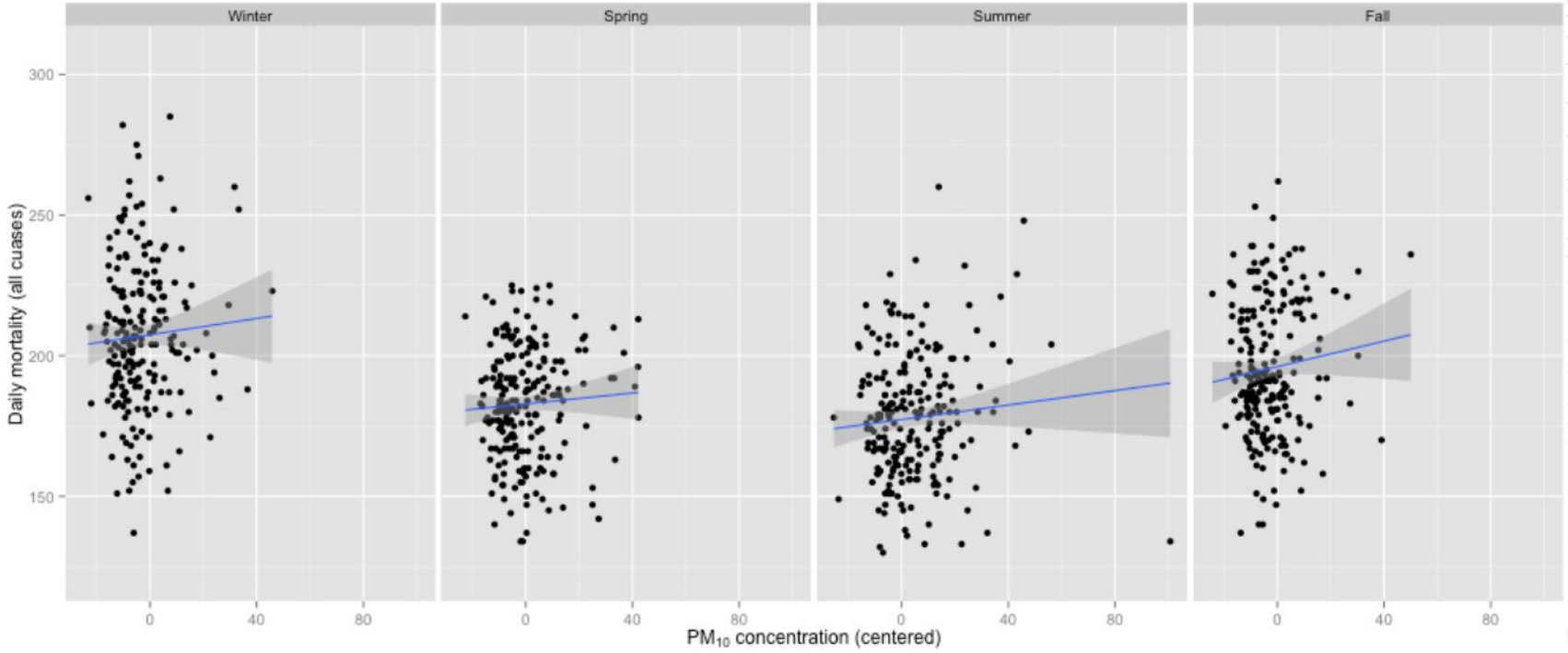
Show Multivariate Data



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Simpson's Paradox

Google it!

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Principles of Analytic Graphics

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- **Principle 2**: Show causality, mechanism, explanation, systematic structure
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- **Principle 3**: Show multivariate data
  - Multivariate = more than 2 variables
  - The real world is multivariate
  - Need to "escape flatland"
- **Principal 4**: Integration of evidence
  - Completely integrate words, numbers, images, diagrams
  - Data graphics should make use of many modes of data presentation
  - **Don't let the tool drive the analysis**

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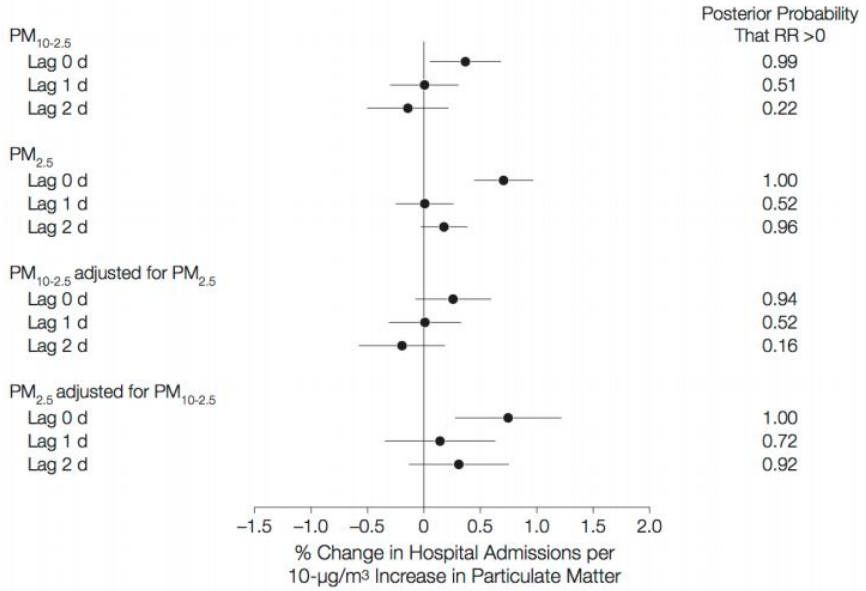
Integrate Different Modes of Evidence

Figure 2. Percentage Change in Emergency Hospital Admissions Rate for Cardiovascular Diseases per a 10-µg/m³ Increase in Particulate Matter



Estimates are on average across 108 counties. $PM_{2.5}$ indicates particulate matter is 2.5 µm or less in aerodynamic diameter; PM_{10}, particulate matter is 10 µm or less in aerodynamic diameter; $PM_{10-2.5}$, particulate matter is greater than 2.5 µm and 10 µm or less in aerodynamic diameter; RR, relative risk. Error bars indicate 95% posterior intervals.

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Principles of Analytic Graphics

- **Principle 5**: Describe and document the evidence with appropriate labels, scales, sources, etc.
  - A data graphic should tell a complete story that is credible
- **Principle 6**: Content is king
  - Analytical presentations ultimately stand or fall depending on the quality, relevance, and integrity of their content

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Why do we use graphs in data analysis?

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Why do we use graphs in data analysis?

- To understand data properties
- To find patterns in data
- To suggest modeling strategies
- To "debug" analyses
- To communicate results

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Why do we use graphs in data analysis?

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Exploratory graphs

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Characteristics of exploratory graphs

- They are made quickly
- A large number are made
- The goal is for personal understanding
- Axes/legends are generally cleaned up
- Color/size are primarily used for information

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Example: Air Pollution in the United States

- The U.S. Environmental Protection Agency (EPA) sets national ambient air quality standards for outdoor air pollution
  - U.S. National Ambient Air Quality Standards
- For fine particle pollution (PM2.5), the "annual mean, averaged over 3 years" cannot exceed 12 $\mu g/m^3$.
- Data on daily PM2.5 are available from the U.S. EPA web site
  - EPA Air Quality System

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Example: Air Pollution in the United States

- **Question**: Are there any counties in the U.S. that exceed that national standard for fine particle pollution?

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Data

Annual average PM2.5 averaged over the period 2008 through 2010

```
##     pm25  fips region longitude latitude
## 1  9.771 01003   east    -87.75    30.59
## 2  9.994 01027   east    -85.84    33.27
## 3 10.689 01033   east    -87.73    34.73
## 4 11.337 01049   east    -85.80    34.46
## 5 12.120 01055   east    -86.03    34.02
## 6 10.828 01069   east    -85.35    31.19
```

Do any counties exceed the standard of 12 $\mu g/m^3$?

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Simple Summaries of Data

One dimension

- Five-number summary
- Boxplots
- Histograms
- Density plot
- Barplot

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Five Number Summary

```
summary(pollution$pm25)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    3.38    8.55   10.00    9.84   11.40   18.40
```

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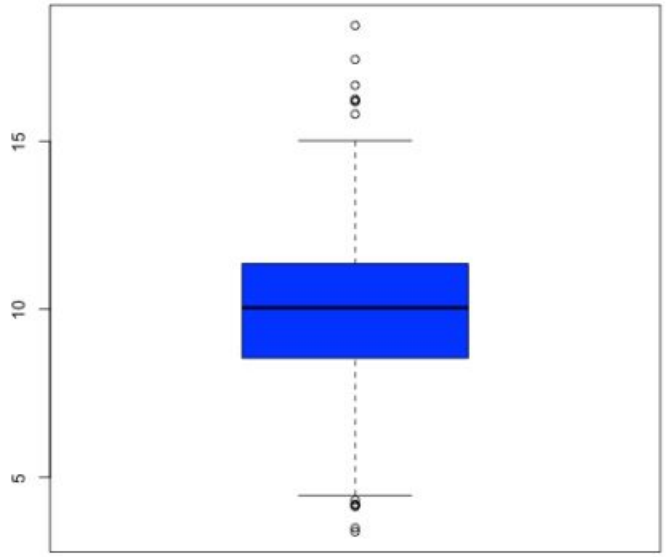
Boxplot

```
boxplot(pollution$pm25, col = "blue")
```



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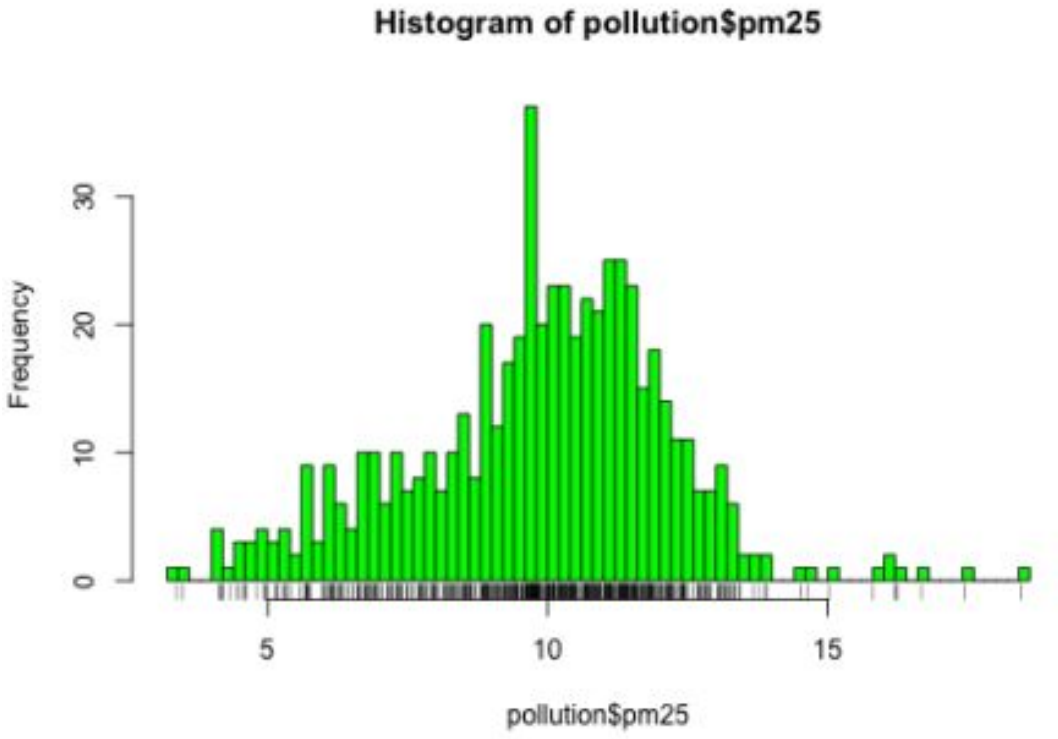
Histogram



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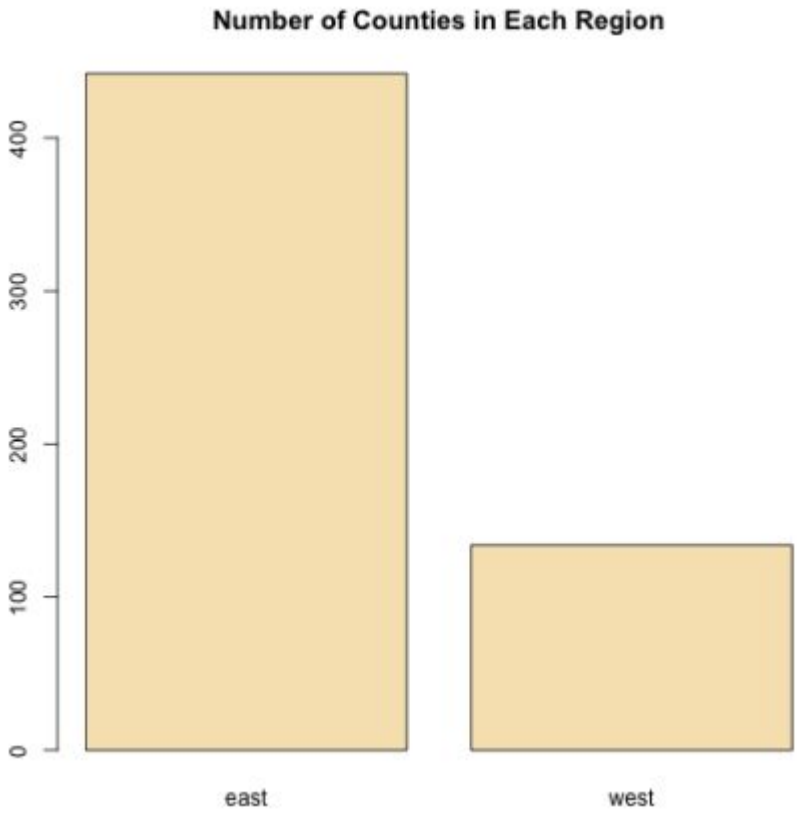
Barplot



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Simple Summaries of Data

Two dimensions

- Multiple/overlayed 1-D plots (Lattice/ggplot2)
- Scatterplots
- Smooth scatterplots

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Simple Summaries of Data

> 2 dimensions

- Overlayed/multiple 2-D plots; coplots
- Use color, size, shape to add dimensions
- Spinning plots
- Actual 3-D plots (not that useful)

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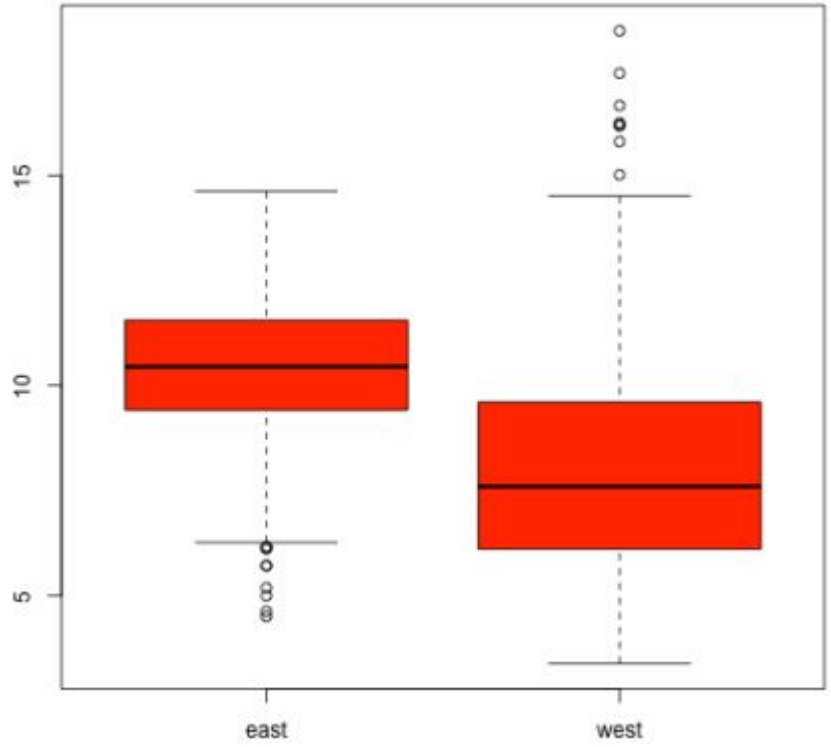
Multiple Boxplots



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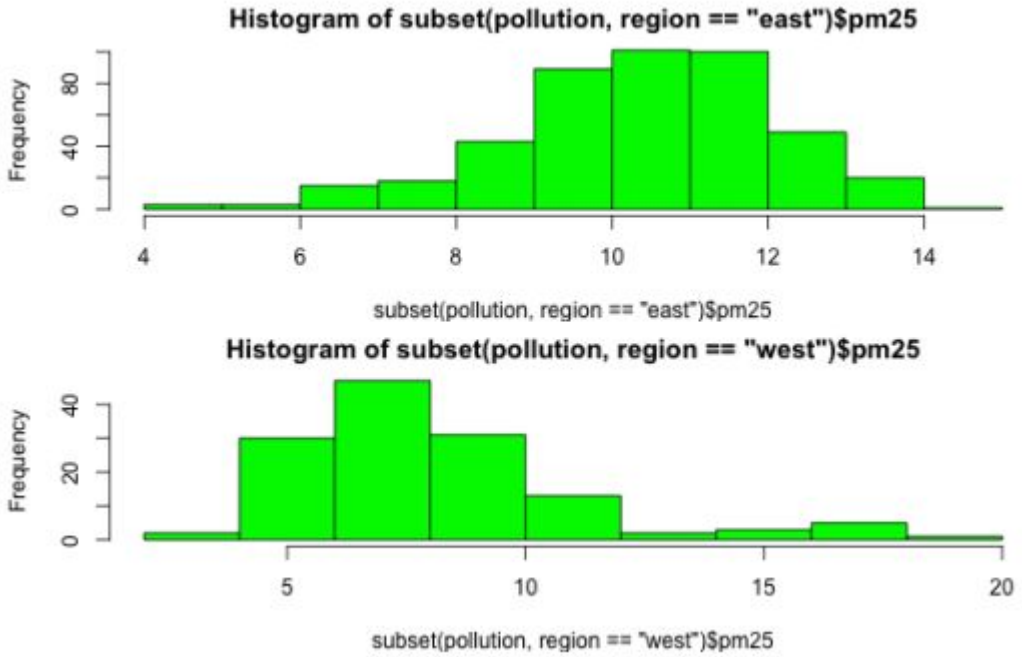
Multiple Histograms



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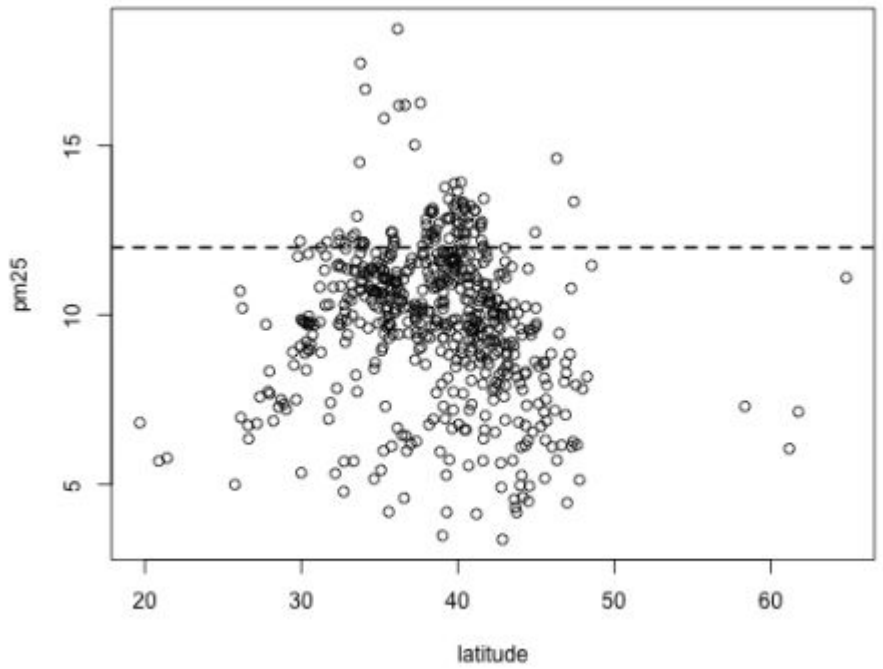
Scatterplot



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Summary

- Exploratory plots are "quick and dirty"
- Let you summarize the data (usually graphically) and highlight any broad features
- Explore basic questions and hypotheses (and perhaps rule them out)
- Suggest modeling strategies for the "next step"

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Thanks!

Machine Learning for Data Science Interest Group
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