Data Preparation

Paul Rodriguez

On the Importance of Data Prep

- "Garbage in, garbage out"
- Sometimes takes 60-80% of the whole data mining effort

Working definition

- **Data Preparation:**
  - Cleaning
  - Filtering
  - Transforming
  - Organizing the data matrix (aka ‘data wrangling’ or ‘data munging’)

In a nutshell, preparing data for modeling

Cleaning Noise

- Entity Resolution and Record Linkage

e.g. Are these equal?

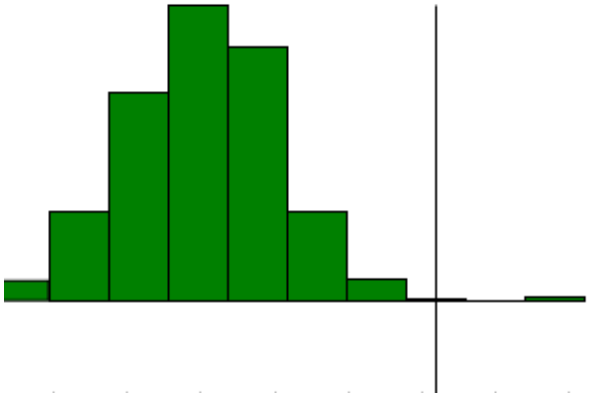
West Main Street ***W Main St***

Strategy:
use dictionaries and search possible matches

Statistical Noise:

- Outliers

e.g. remove them,

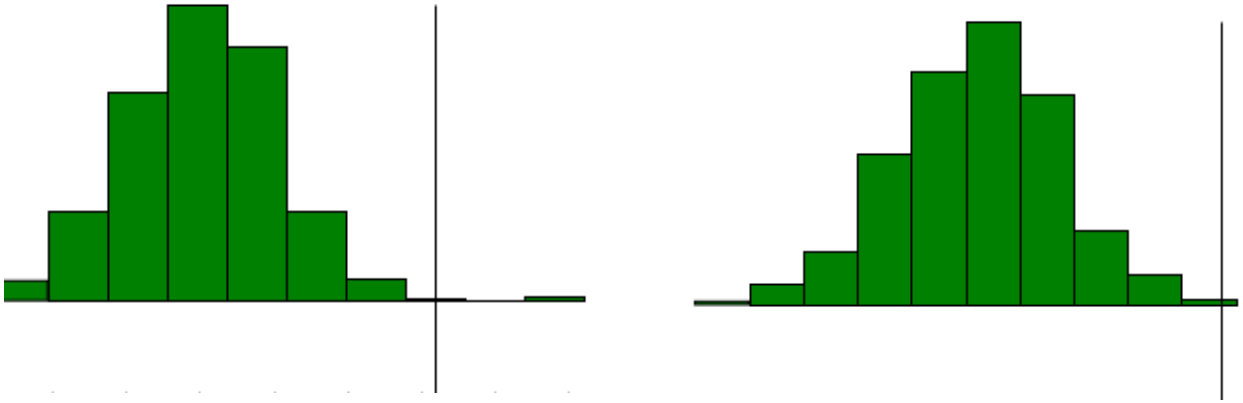


mean + 3*std-devm

Statistical Noise:

- Outliers

e.g. remove them, but cutoff sometimes seems arbitrary



mean + 3*std-devm

Missing Data

- **Important to review frequency counts of a missing variable**
  - Are entries missing completely at random or contingent on some other variable?
  - Is there a relation between missing cases and outcome variable?

Missing Data (NA vs NULL)

- **Not applicable - NA**

  e.g. spouse name depends on marital status

- **Not available - NULL**

  unknown

  not entered

Missing Data

- Do missing cases depend on some other variable?

  e.g. ‘CEOs’ don’t like to list their salary

Strategy: *get most common job titles*

for missing salaries

Quick Approaches

- Delete instances

and/or

- Delete attributes with high missingness

Quick Approaches

- Leave as ‘NULL’ category
  - Some algorithms implementation handle NULL (ie Decision Trees)

Simple Imputation

- Use the attribute mean (by class)

Complicated Imputation

- Use a model (based on other attributes) to infer missing value

Complicated Imputation

- Use a model (based on other attributes) to infer missing value

Best strategy depends on

time vs accuracy tradeoffs

R and missing data

- **Several packages, such as ‘mice’ , ‘amelia’**
- **Produces multiple data sets**
- **Iterates over missing data estimates and linear model estimates**
  - Mice uses Gibbs sampling (slower)
  - Amelia uses Expectation Maximization (faster)
- **Beware of correlation in variables**
  - Matrices not invertible

R and missing data

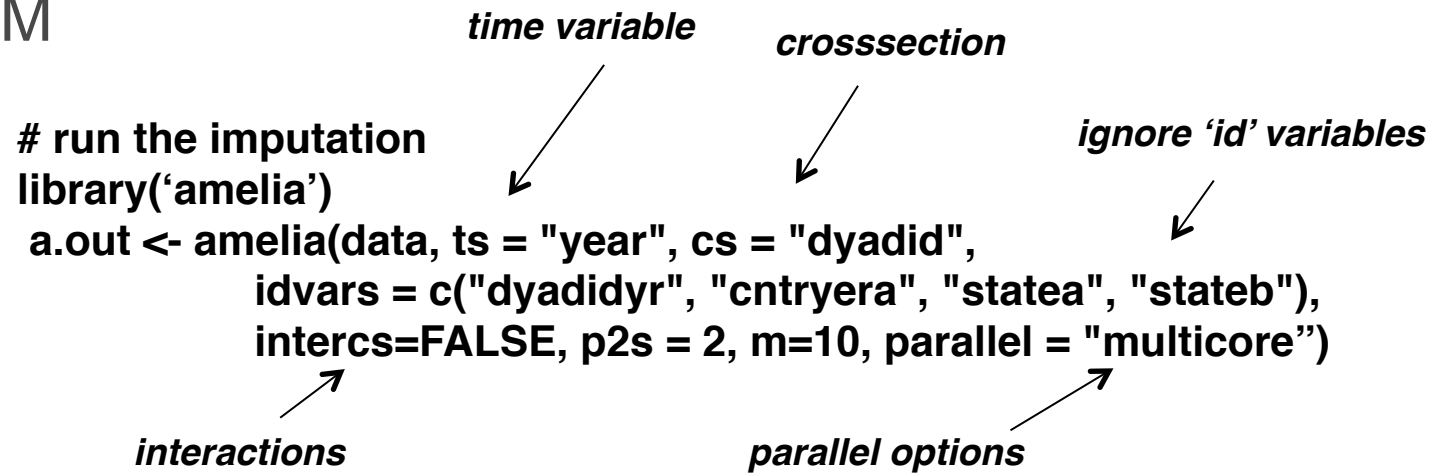
- **Sample R code using Amelia:**

  Data: UN conflict data in pairs of countries

  300K rows ~ 1 hour on Gordon compute node (not run on the user's PC)

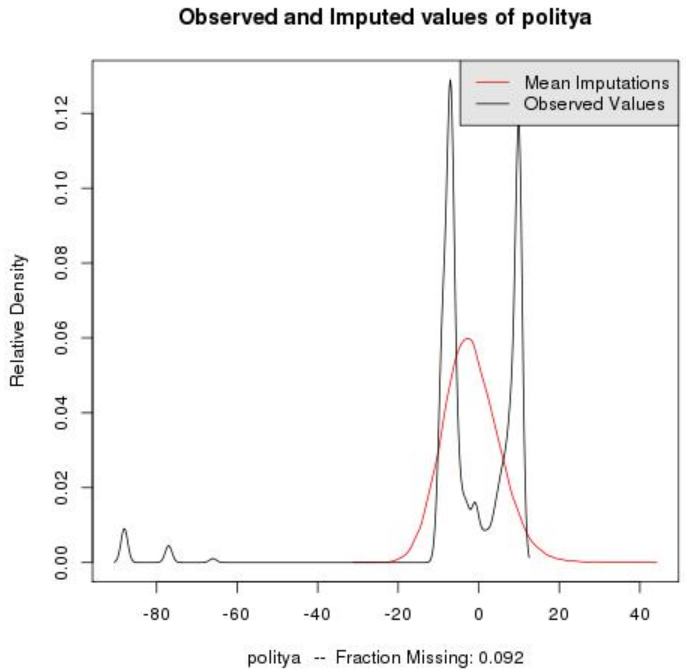
  1K-100K entries missing per col for about 20 of 50 cols

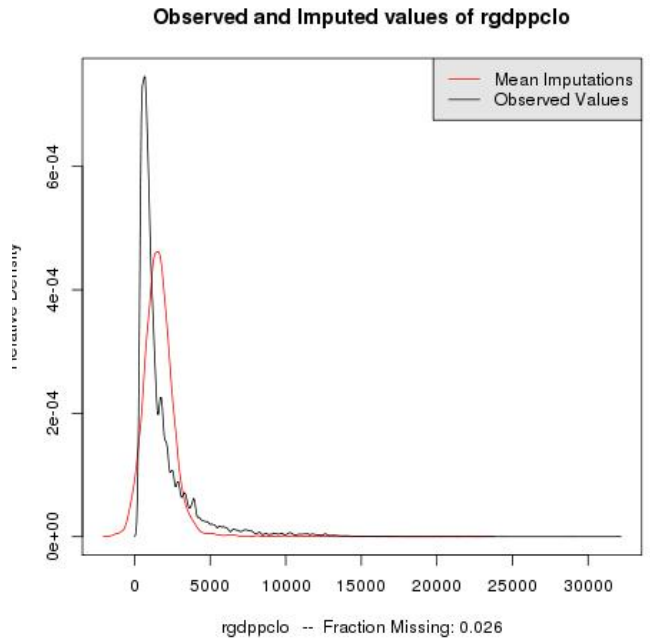
  Note: mice package is probably more well known, and has similar options, but MCMC is slower than EM



R and missing data

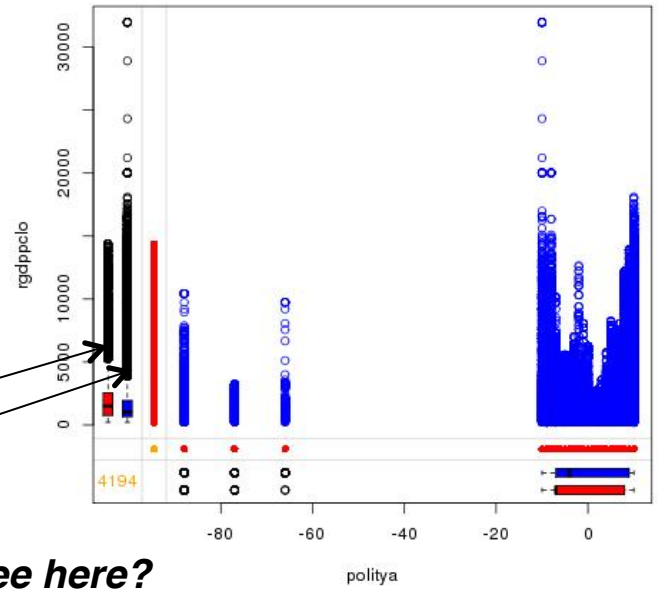
#QA on missing data by comparing density of imputated & original data
compare.density(a.out, var="politya")
compare.density(a.out,var='rgdpcontg')





R and missing data

```
# Useful library for printing margin plots, to compare histograms
#                    conditional on missing/non-missing data
library('VIM')
marginplot(gart2use[,c('politya', 'rgdppclo')],
  col=c('blue','red','orange')
```



dist of rgdppclo when politya missing

politya present

What would you want to see here?

Variable Transformations

- **Engineer new features**
- **Combine attributes**
  e.g. rates and ratios
- **Normalize or Scale data**
- **D**iscretize data
  (perhaps more intuitive to deal with binned data)

Feature Engineering is Variable Enhancement

- **Use Domain and world knowledge**
- **Examples:**

  given date and location of doctor visits

  - deduce a new variable for Number-of-1st-time-visits
  - deduce a new variable for Number-of-visits-over-25-miles
  - deduce a new variable for Amount-of-time-between-visits

Re-scaling

- **Mean center** $x_{new} = x - \text{mean}(x)$
- **z-score** $score = \frac{x - \text{mean}(x)}{\text{std}(x)}$
- **Scale to [0…1]** $x_{new} = \frac{x - \min(x)}{\max(x) - \min(x)}$
- **log scaling** $x_{new} = \log(x)$

Variable selection

- **Heuristic methods:**

  remove variables with low correlations to outcome

  (other criteria: information gain, sensitivity, etc…)

  - step wise: add 1 variable at a time and test algorithm on samples

Variable selection

- **Some algorithms are robust to extra noise variables**

- E.g. Least Angle Regression (L_1 penalty),

- penalize small effect sizes (zero them out)

- E.g. Random Forest outputs 'importance'

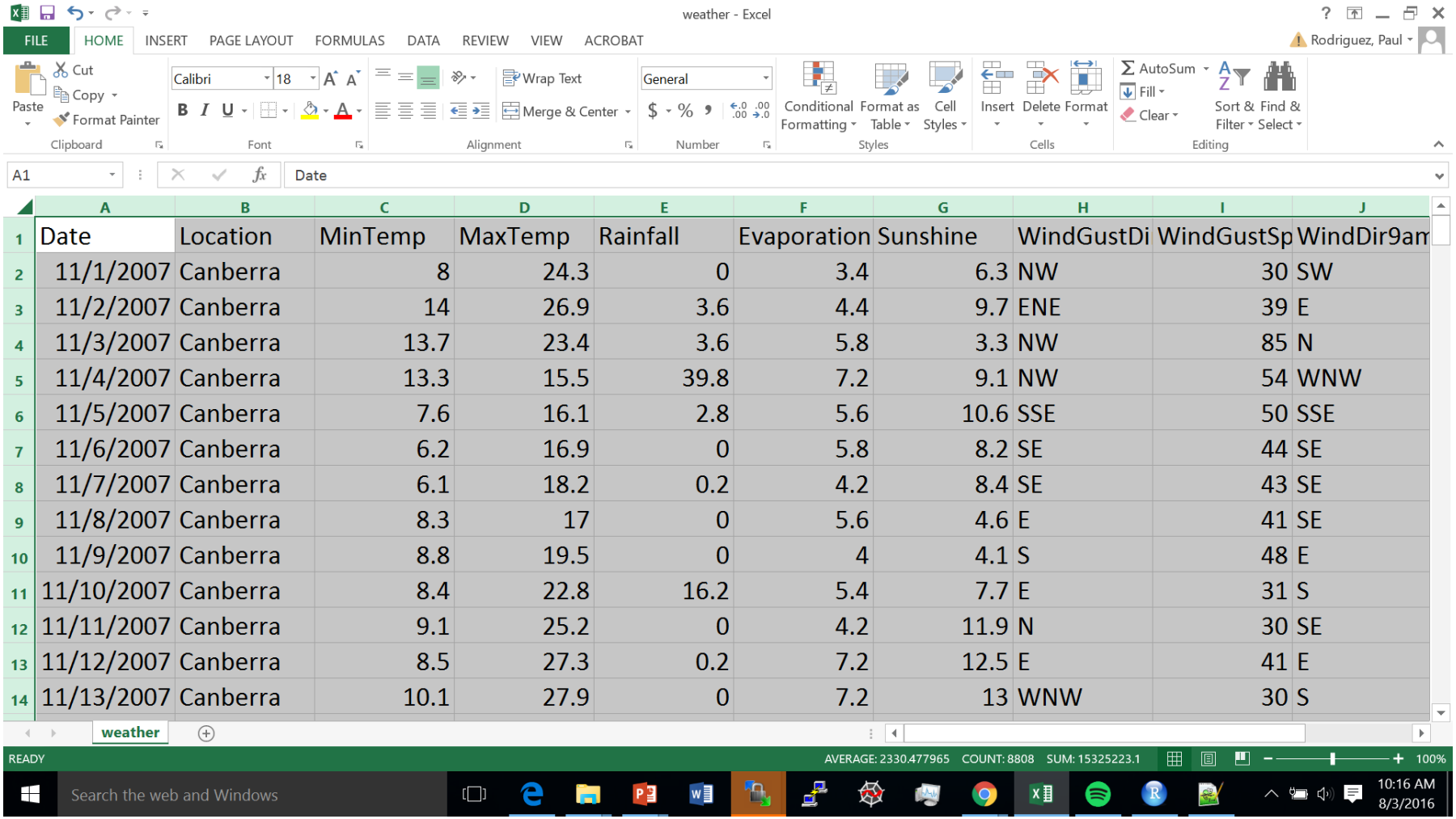
- low importance implies non-influence in the model

  (other criteria: information gain, sensitivity, etc…)

Summary

- Preparing data is based on statistical principles,
- But also heuristics

Data Prep Exercise: Weather Data



	A	B	C	D	E	F	G	H	I	J
1	Date	Location	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustDi	WindGustSp	WindDir9am
2	11/1/2007	Canberra	8	24.3	0	3.4	6.3	NW	30	SW
3	11/2/2007	Canberra	14	26.9	3.6	4.4	9.7	ENE	39	E
4	11/3/2007	Canberra	13.7	23.4	3.6	5.8	3.3	NW	85	N
5	11/4/2007	Canberra	13.3	15.5	39.8	7.2	9.1	NW	54	WNW
6	11/5/2007	Canberra	7.6	16.1	2.8	5.6	10.6	SSE	50	SSE
7	11/6/2007	Canberra	6.2	16.9	0	5.8	8.2	SE	44	SE
8	11/7/2007	Canberra	6.1	18.2	0.2	4.2	8.4	SE	43	SE
9	11/8/2007	Canberra	8.3	17	0	5.6	4.6	E	41	SE
10	11/9/2007	Canberra	8.8	19.5	0	4	4.1	S	48	E
11	11/10/2007	Canberra	8.4	22.8	16.2	5.4	7.7	E	31	S
12	11/11/2007	Canberra	9.1	25.2	0	4.2	11.9	N	30	SE
13	11/12/2007	Canberra	8.5	27.3	0.2	7.2	12.5	E	41	E
14	11/13/2007	Canberra	10.1	27.9	0	7.2	13	WNW	30	S

Data Prep exercise

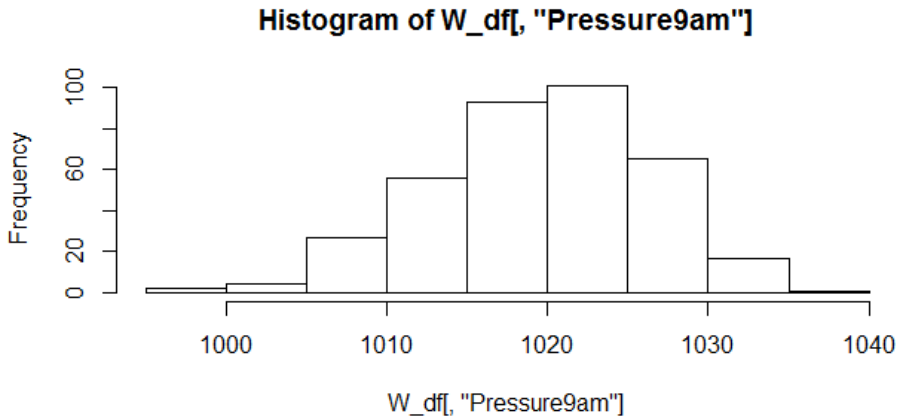
```
W_df = read.table('weather.csv',
                  header=TRUE,
                  sep=",",
                  stringsAsFactors = TRUE)
```

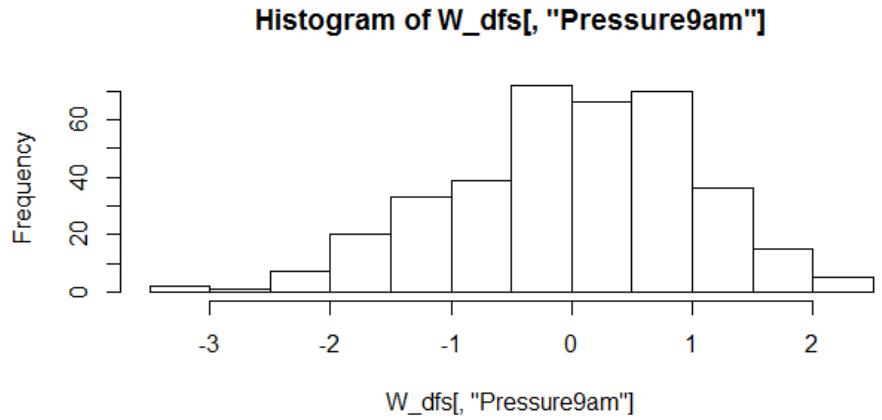
#Try: run the summary command, what do you notice about the ranges of variables?

```
#Let do some normalization
#Make a function
myscale = function(x)
        if (class(x)=='integer' || class(x)=='numeric') {
                (x-mean(x,na.rm=T)) / sd(x,na.rm=T) }
        else { x}

#get a new dataframe and replace with normalized
#       values
W_dfs = W_df
for (i in num_classes)
                { W_dfs[,i]=myscale(W_dfs[,i])}
```

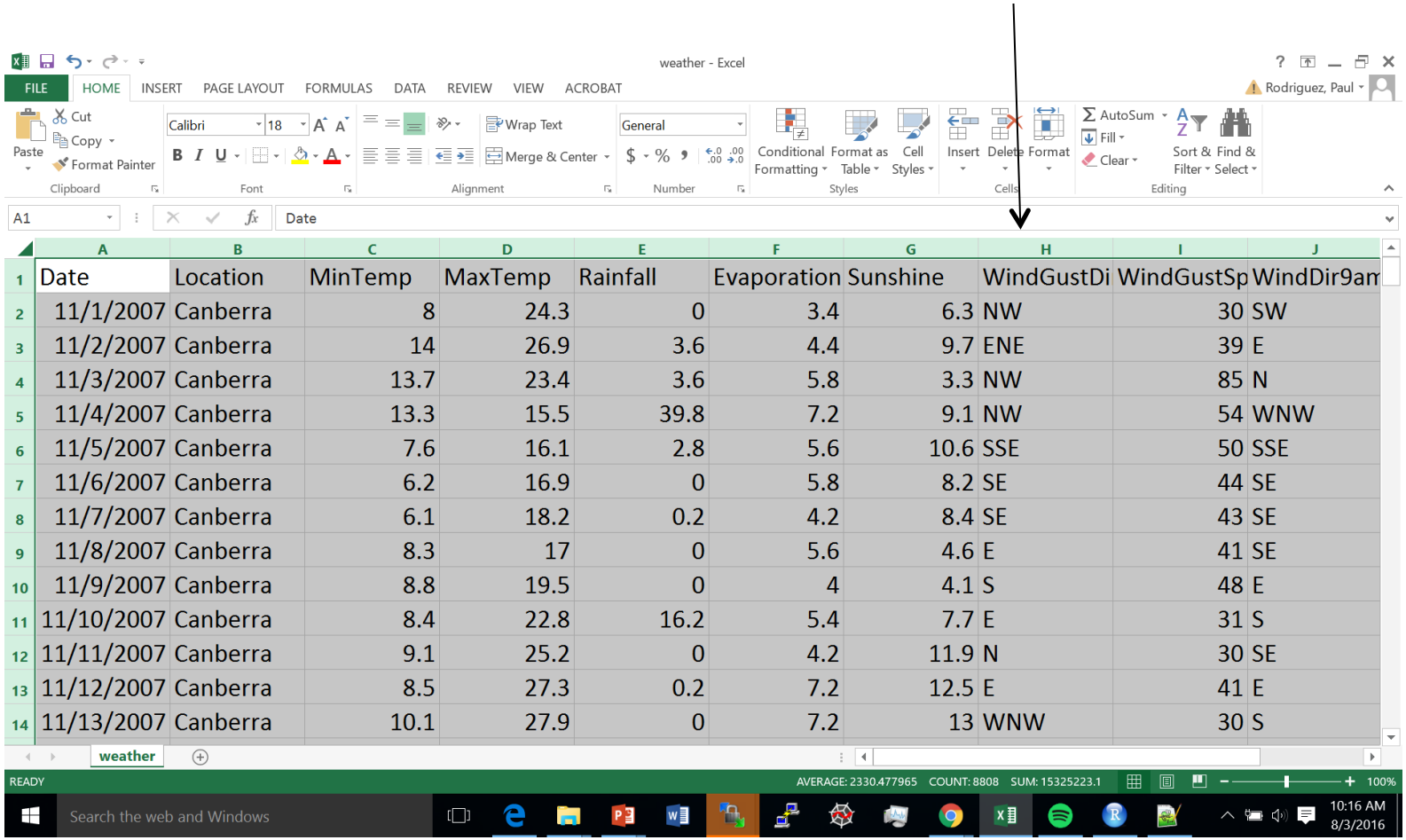
hist(W_df[,'Pressure9am'])





Transforming Weather Data Matrix

Let's consider WindGustDir as if it's a repeated measurement



weather - Excel

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1	Date	Location	MinTemp	MaxTemp	Rainfall	Evaporation	Sunshine	WindGustDi	WindGustSp	WindDir9am
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4	11/3/2007	Canberra	13.7	23.4	3.6	5.8	3.3	NW	85	N
5	11/4/2007	Canberra	13.3	15.5	39.8	7.2	9.1	NW	54	WNW
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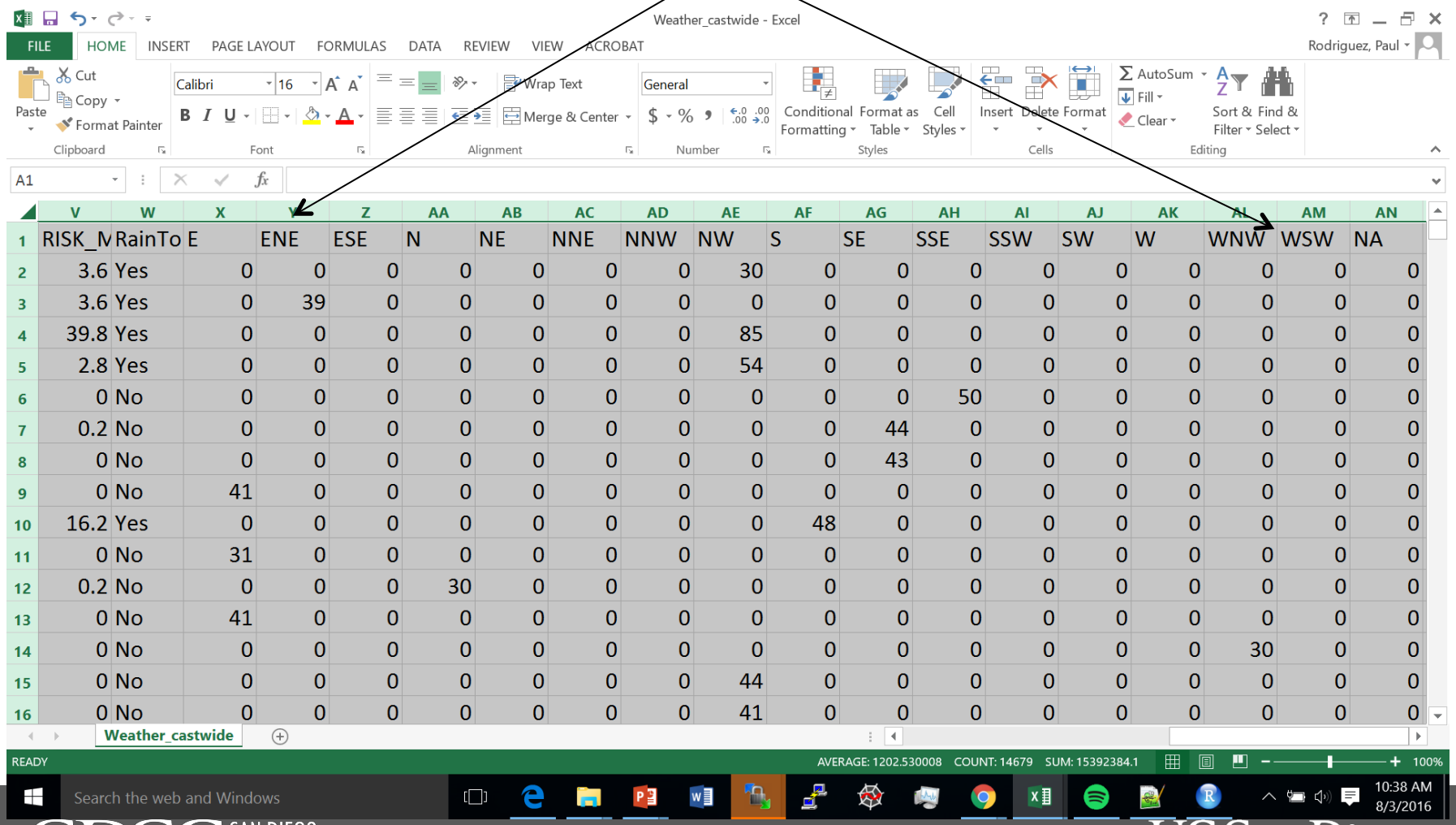
Transforming Weather Data Matrix

Now: WindGustDir values each have their own column



Weather_castwide - Excel

	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN
1	RISK_M	RainTo	E	ENE	ESE	N	NE	NNE	NNW	NW	S	SE	SSE	SSW	SW	W	WNW	WSW	NA
2	3.6	Yes	0	0	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0
3	3.6	Yes	0	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	39.8	Yes	0	0	0	0	0	0	0	85	0	0	0	0	0	0	0	0	0
5	2.8	Yes	0	0	0	0	0	0	0	54	0	0	0	0	0	0	0	0	0
6	0	No	0	0	0	0	0	0	0	0	0	0	50	0	0	0	0	0	0
7	0.2	No	0	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0
8	0	No	0	0	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0
9	0	No	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	16.2	Yes	0	0	0	0	0	0	0	0	48	0	0	0	0	0	0	0	0
11	0	No	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0.2	No	0	0	0	30	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	No	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	No	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0
15	0	No	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0
16	0	No	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0

```
install.packages('reshape2')
library(reshape2)

# long-to-wide: 'cast' repeated measure into wide table
W_cast   =dcast(W_df,
        formula=Date+Location+ ...~ WindGustDir,
        fill=0,
        value.var="WindGustSpeed")
```

WindGustDir distinguished the repeated measures

WindGustSpeed has the actual values

Extra to try:

```
# wide to long: ie 'melt' repeated measure into long
#          table
W_melt   =melt(W_cast,
        na.rm=TRUE,
        measure.vars=c(23:39),
        variable.name="WindGustDir_cast")
```

The repeated measures are now in columns 23 to 30

pause

Reading Material

- **Data Preparation for Data Mining by Dorian Pyle**
  - http://www.ebook3000.com/Data-Preparation-for-Data-Mining_88909.html
- **Data mining – Practical Machine learning tools and techniques by Witten & Frank**
  - http://books.google.com