# Data Cleaning
for the
Kelowna Weather-Crash Project

Contents

1 Introduction

Here I present the data cleaning for each dataset, as well as the process of combining the datasets.

2 Weather Data

Loading in weather data:

```
> fullWeather = c()
> for (i in c(2017:2021)){
+   for (j in c(1:12)){
+     temp = subset(read.csv(paste0('../../weatherdata/en_climate_hourly_BC_1123939_',
+       sprintf("%02d", j), '-', i, '_P1H.csv')),
+       select = - c(`Temp.Flag`,
+       `Dew.Point.Temp.Flag`, `Rel.Hum.Flag`,
+       `Precip..Amount.Flag`, `Wind.Dir.Flag`,
+       `Wind.Spd.Flag`, `Visibility.Flag`,
+       `Stn.Press.Flag`, `Hmdx`, `Hmdx.Flag`, `Wind.Chill.Flag`))
+     fullWeather = rbind(fullWeather, temp)
+   }
+ }
> nrow(fullWeather)
```

```
[1] 43824
```

```
> 24*365*5 + 24 #2020 was a leap year
```

```
[1] 43824
```

```
> #assigning a Julian day variable
> library(lubridate)
> fullWeather$julianday = yday(as.Date(fullWeather$Date.Time..LST., tz='LST'))
> summary(fullWeather)
```

```
 Longitude..x.     Latitude..y.    Station.Name      Climate.ID
 Min.   :-119.4   Min.   :49.96   KELOWNA:43824   Min.   :1123939
 1st Qu.:-119.4   1st Qu.:49.96                   1st Qu.:1123939
 Median :-119.4   Median :49.96                   Median :1123939
 Mean   :-119.4   Mean   :49.96                   Mean   :1123939
 3rd Qu.:-119.4   3rd Qu.:49.96                   3rd Qu.:1123939
 Max.   :-119.4   Max.   :49.96                   Max.   :1123939

         Date.Time..LST.        Year          Month             Day
 2017-01-01 00:00:     1   Min.   :2017   Min.   : 1.000   Min.   : 1.00
 2017-01-01 01:00:     1   1st Qu.:2018   1st Qu.: 4.000   1st Qu.: 8.00
 2017-01-01 02:00:     1   Median :2019   Median : 7.000   Median :16.00
 2017-01-01 03:00:     1   Mean   :2019   Mean   : 6.524   Mean   :15.73
 2017-01-01 04:00:     1   3rd Qu.:2020   3rd Qu.:10.000   3rd Qu.:23.00
 2017-01-01 05:00:     1   Max.   :2021   Max.   :12.000   Max.   :31.00
 (Other)          :43818
   Time..LST.       Temp...C.        Dew.Point.Temp...C.  Rel.Hum....
 00:00   : 1826   Min.   :-28.900   Min.   :-32.800     Min.   : 12.00
 01:00   : 1826   1st Qu.:  0.800   1st Qu.: -2.100     1st Qu.: 52.00
 02:00   : 1826   Median :  7.800   Median :  2.300     Median : 74.00
 03:00   : 1826   Mean   :  8.511   Mean   :  2.043     Mean   : 69.33
 04:00   : 1826   3rd Qu.: 15.700   3rd Qu.:  7.500     3rd Qu.: 89.00
 05:00   : 1826   Max.   : 43.800   Max.   : 19.700     Max.   :100.00
```

```
(Other):32868   NA's   :30        NA's   :29          NA's   :24
Precip..Amount..mm. Wind.Dir..10s.deg. Wind.Spd..km.h.  Visibility..km.
Min.   :0.00000     Min.   : 1.00      Min.   : 0.000   Min.   : 0.0
1st Qu.:0.00000     1st Qu.: 9.00      1st Qu.: 4.000   1st Qu.:16.1
Median :0.00000     Median :18.00      Median : 5.000   Median :16.1
Mean   :0.02999     Mean   :19.13      Mean   : 8.415   Mean   :15.1
3rd Qu.:0.00000     3rd Qu.:33.00      3rd Qu.:11.000   3rd Qu.:16.1
Max.   :7.10000     Max.   :36.00      Max.   :58.000   Max.   :16.1
NA's   :24          NA's   :13955      NA's   :52       NA's   :31
Stn.Press..kPa.   Wind.Chill         Weather        julianday
Min.   :93.73   Min.   :-34.00   Rain    : 2069   Min.   :  1.0
1st Qu.:96.10   1st Qu.:-11.00   Snow    : 1662   1st Qu.: 92.0
Median :96.52   Median : -6.00   Haze    : 1187   Median :183.0
Mean   :96.55   Mean   : -8.22   Fog     :  873   Mean   :183.1
3rd Qu.:96.96   3rd Qu.: -4.00   Rain,Fog:  233   3rd Qu.:274.0
Max.   :99.34   Max.   : -1.00   (Other) :  246   Max.   :366.0
NA's   :34      NA's   :36294    NA's    :37554
```

There are 22 empty strings in the `Weather` variable that should be NAs.

```
> length(fullWeather[fullWeather$Weather == "" &
+                is.na(fullWeather$Weather) == FALSE, "Weather"])

[1] 22

> ## SETTING EMPTY TO NA
> fullWeather$Weather[fullWeather$Weather == "" &
+                is.na(fullWeather$Weather) == FALSE] = NA
> ## CHECKING
> length(fullWeather[fullWeather$Weather == "" &
+                is.na(fullWeather$Weather) == FALSE, "Weather"])

[1] 0
```

Need to relevel factor to remove empty string option:

```
> "" %in% levels(fullWeather$Weather)

[1] TRUE

> fullWeather$Weather = droplevels(fullWeather$Weather)
> "" %in% levels(fullWeather$Weather)

[1] FALSE
```

Changing `Weather` factor variable to many indicator variables.

```
> #creating columns
> lst = c()
> for (i in levels(fullWeather$Weather)){
+   temp = unlist(strsplit(as.character(i), ","))
+   lst = c(lst, temp)
+ }
> lst = lst[!(duplicated(lst))] #removing duplicates
> lst

 [1] "Fog"           "Freezing Fog"  "Freezing Rain" "Snow"
 [5] "Haze"          "Rain"          "Moderate Snow" "Moderate Rain"
 [9] "Thunderstorms" "Heavy Rain"    "Heavy Snow"    "Blowing Snow"

> for (i in lst){
+   fullWeather[, i] = factor("0", levels = c("0", "1"))
+ }
> names(fullWeather)

 [1] "Longitude..x."       "Latitude..y."        "Station.Name"
 [4] "Climate.ID"          "Date.Time..LST."     "Year"
 [7] "Month"               "Day"                 "Time..LST."
[10] "Temp...C."           "Dew.Point.Temp...C." "Rel.Hum...."
[13] "Precip..Amount..mm." "Wind.Dir..10s.deg."  "Wind.Spd..km.h."
[16] "Visibility..km."     "Stn.Press..kPa."     "Wind.Chill"
[19] "Weather"             "julianday"           "Fog"
[22] "Freezing Fog"        "Freezing Rain"       "Snow"
[25] "Haze"                "Rain"                "Moderate Snow"
[28] "Moderate Rain"       "Thunderstorms"       "Heavy Rain"
[31] "Heavy Snow"          "Blowing Snow"

> ############
>
> #assigning values
> for (i in 1:nrow(fullWeather)){
+   if (!is.na(fullWeather$Weather[i])){
+     temp = as.character(fullWeather$Weather[i])
+     temp = unlist(strsplit(temp, ","))
+     for (j in temp){
+       fullWeather[i, j] = "1"
+     }
+   }
+ }
> ###########
>
> #collapsing to only: Rain, Snow, Thunderstorms, Fog, Freezing Rain
> fullWeather$Rain[fullWeather$'Moderate Rain' == 1] = 1
> fullWeather$Rain[fullWeather$'Heavy Rain' == 1] = 1
> fullWeather$Snow[fullWeather$'Moderate Snow' == 1] = 1
> fullWeather$Snow[fullWeather$'Heavy Snow' == 1] = 1
> fullWeather$Snow[fullWeather$'Blowing Snow' == 1] = 1
> fullWeather$Fog[fullWeather$'Freezing Fog' == 1] = 1
> fullWeather$Fog[fullWeather$'Haze' == 1] = 1
> fullWeather = subset(fullWeather, select = - c(`Moderate Rain`,
+               `Heavy Rain`, `Moderate Snow`, `Heavy Snow`,
+               `Blowing Snow`, `Freezing Fog`, `Haze`))
> summary(fullWeather[,c("Weather", "Rain", "Fog", "Snow",
+                        "Thunderstorms", "Freezing Rain")])
```

```
     Weather      Rain      Fog       Snow      Thunderstorms Freezing Rain
 Rain    : 2069   0:41370   0:41429   0:42132   0:43794       0:43819
 Snow    : 1662   1: 2454   1: 2395   1: 1692   1:   30       1:    5
 Haze    : 1187
 Fog     :  873
 Rain,Fog:  233
 (Other) :  224
 NA's    :37576
```

I realize that I could have used a regex solution here to shorten the code, but the solution above is more general. This is important if I wanted to add/remove groups to/from the reduced list of weather types later on (ie. adding 'Heavy Snow').

*Note that I kept `Rain` and `Freezing Rain` separate and mutually exclusive. Therefore, if an hour had freezing rain, the indicator variables will have "1" for `Freezing Rain`, and a "0" for `Rain`.

Testing if any hours have precipitation without the appropriate `Weather` variable:

```
> precip = which(fullWeather$Precip..Amount..mm. > 0 &
+                      is.na(fullWeather$Precip..Amount..mm.) == FALSE &
+                      is.na(fullWeather$Weather)
+ ) #gives rows that have precip but NA for weather
> length(precip)

[1] 356
```

There are 356 cases where there is precipitation but no associated `Weather` variable!

To fix this, we want to assign the appropriate `Weather` depending on the temperature. However, this is easier said than done. At what temperature does it snow versus rain?

We can ask the data:

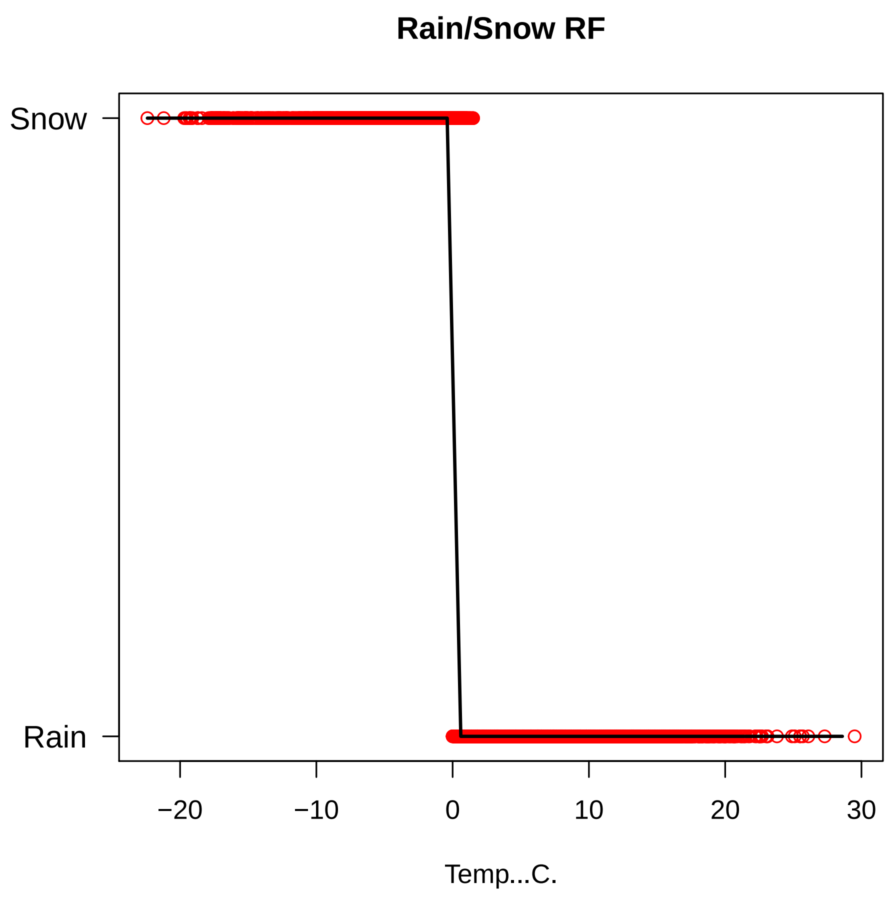
```
> fullWeather$actual = NA
> for (i in 1:nrow(fullWeather)){
+   if (fullWeather$Rain[i] == 1){
+     fullWeather$actual[i] = 'Rain'
+   }
+   if (fullWeather$Snow[i] == 1){
+     fullWeather$actual[i] = 'Snow'
+   }
+ }
> assign = function(x){
+   if (is.na(x)){
+     return(NA)
+   }
+   if (x > 0){
+     return("Above 0")
+   } else {
+     return("Below 0")
+   }
+ }
> #classification table
> fullWeather$expected = sapply(fullWeather$Temp...C., assign)
> rainsnow = table(fullWeather$expected, fullWeather$actual)
> rainsnow

          Rain Snow
  Above 0 2438  202
  Below 0    3 1490

> #probabilities
> #chance of raining if above 0
> rainprob = rainsnow[1,1]/(rainsnow[1,1]+rainsnow[1,2])
> rainprob

[1] 0.9234848

> #chance of snowing if below 0
> snowprob = rainsnow[2,2]/(rainsnow[2,2]+rainsnow[2,1])
> snowprob
```

```
[1] 0.9979906
```

In other words, whenever the temperature is above 0, it is usually raining (0.92%). Similarly, whenever the temperature is below 0, it is basically always snowing (0.998%).

Therefore, we could assign our missing values based on these probabilities. However, it is intuitively true that as you get further from zero, these probabilities would change. Therefore, we can just use a random forest model to predict whether or not it will be snowing or raining based on the temperature:

```
> training = subset(fullWeather[-precip,],
+                   subset = (is.na(fullWeather$actual[-precip]) == FALSE),
+                   select=c('Temp...C.', 'actual'))
> training$actual = as.factor(training$actual)
> library(randomForest)
> RFmodel = randomForest(actual~Temp...C., data=training, importance=TRUE)
> RFmodel

Call:
 randomForest(formula = actual ~ Temp...C., data = training, importance = TRUE)
               Type of random forest: classification
                     Number of trees: 500
No. of variables tried at each split: 1

        OOB estimate of  error rate: 2.93%
Confusion matrix:
     Rain Snow class.error
Rain 2366   75  0.03072511
Snow   46 1646  0.02718676

> plot(training, col='red', main="Rain/Snow RF", yaxt='n', ylab="")
> test = min(training$Temp...C.):max(training$Temp...C.)
> lines(test, predict(RFmodel,
+                     data.frame(Temp...C. = test), type = "response"), lwd=2)
> axis(side = 2, at = c(1,2), labels = c('Rain', 'Snow'), cex.axis=1.2, las=1)
> #predicting missing (precip) values
> rainsnowpredict = predict(RFmodel,
+                   fullWeather[precip,], type = "response")
> #old Rain and Snow variables
> summary(fullWeather$Rain)

    0     1
41370  2454

> summary(fullWeather$Snow)

    0     1
42132  1692

> #adding predictions
> #where 0 = raining and 1 = snowing
> for (i in names(rainsnowpredict)){
+   if (rainsnowpredict[i] == 'Rain'){
+     fullWeather[as.numeric(i), 'Rain'] = 1
+     fullWeather[as.numeric(i), 'Weather'] = 'Rain'
+   } else {
+     fullWeather[as.numeric(i), 'Snow'] = 1
+     fullWeather[as.numeric(i), 'Weather'] = 'Snow'
+   }
+ }
> #new Rain and Snow variables
> summary(fullWeather$Rain)

    0     1
41065  2759

> summary(fullWeather$Snow)

    0     1
42081  1743

> #checking that it worked
> length(which(fullWeather$Precip..Amount..mm. > 0 &
+                      is.na(fullWeather$Precip..Amount..mm.) == FALSE &
+                      is.na(fullWeather$Weather)))

[1] 0
```



3 Crash Data

Loading in crash data:

```
> fullCrash = subset(read.csv('../../crashdata/Southern Interior_Full Data_data.csv'),
+           select = - c(`Crash.Breakdown.2`, `Region`,
+                        `Municipality.Name..ifnull.`))
> summary(fullCrash)
```

```
 Date.Of.Loss.Year Animal.Flag              Crash.Severity  Cyclist.Flag
 Min.   :2017      No :54118   CASUALTY CRASH      :11473   No :55725
 1st Qu.:2018      Yes: 2018   PROPERTY DAMAGE ONLY:44663   Yes:  411
 Median :2019
 Mean   :2019
 3rd Qu.:2020
 Max.   :2021

    Day.Of.Week                Derived.Crash.Configuration Heavy.Veh.Flag
 FRIDAY   :9316   REAR END                    :13024       No :54085
 MONDAY   :8024   SINGLE VEHICLE              :12495       Yes: 2051
 SATURDAY :6753   UNDETERMINED                :11453
 SUNDAY   :5464   SIDE IMPACT                 :11369
 THURSDAY :9061   CONFLICTED                  : 3068
 TUESDAY  :8728   SIDE SWIPE - SAME DIRECTION: 1833
 WEDNESDAY:8790   (Other)                     : 2894
 Intersection.Crash  Month.Of.Year   Motorcycle.Flag Parked.Vehicle.Flag
 No :31677          JULY    : 5152   No :55673       No :38567
 Yes:24459          DECEMBER: 5095   Yes:  463       Yes:17569
                    JANUARY : 5063
                    AUGUST  : 4907
                    OCTOBER : 4836
                    JUNE    : 4735
                    (Other) :26348
 Parking.Lot.Flag Pedestrian.Flag  Street.Full.Name..ifnull.
 No :37189        No :55790       HWY 97        : 6019
 Yes:18947        Yes:  346       HARVEY AVE    : 3168
                                  HWY 33        : 2064
                                  GORDON DR     : 1921
                                  LAKESHORE RD  : 1372
                                  SPRINGFIELD RD: 1326
                                  (Other)       :40266
     Time.Category      Municipality.Name Road.Location.Description
 12:00-14:59:14870   KELOWNA     :45943   UNKNOWN      : 2211
 15:00-17:59:14473   WEST KELOWNA:10193   HWY 97       : 1961
 09:00-11:59:11021                        HARVEY AVE   : 1670
 18:00-20:59: 5805                        LAKESHORE RD:  932
 06:00-08:59: 5489                        LOUIE DR     :  751
 21:00-23:59: 2684                        HWY 33       :  715
 (Other)    : 1794                        (Other)      :47896
       Street.Full.Name Metric.Selector Total.Crashes   Total.Victims
 HWY 97        : 6019   Min.   :1.000   Min.   :1.000   Min.   :0.0000
 HARVEY AVE    : 3168   1st Qu.:1.000   1st Qu.:1.000   1st Qu.:0.0000
```

```
HWY 33         : 2064   Median :1.000   Median :1.000   Median :0.0000
GORDON DR      : 1921   Mean   :1.006   Mean   :1.006   Mean   :0.2917
LAKESHORE RD   : 1372   3rd Qu.:1.000   3rd Qu.:1.000   3rd Qu.:0.0000
SPRINGFIELD RD: 1326    Max.   :3.000   Max.   :3.000   Max.   :9.0000
(Other)        :40266
```

Now, while the crash data is overall much cleaner out-of-the-box than the weather data, the issue is that this crash dataset was made to be 4-anonymous, as the day of the month is not given. Instead, all we have is the month, year, and day of the week. This means we cannot perfectly know the weather on any given day. This massively reduces the power of any statistical tests that we perform with the data, but without being able to reidentify any of the observations, this is the best that we can do.

A solution to this problem would be to randomly assign each of the 4 (or 5) possible weather conditions in each month to each of the corresponding possible days. A better alternative would be to average the weather conditions on each of the possible 4 days and then assign this same (averaged) weather condition to all 4 (or 5) days in that month. The precipitation type (rain, snow, fog, etc.) would then also be averaged (2 snows + 1 rain = snow) with a priority rating (1 snow + 1 rain = snow).

In order to do this, we will need to create a new column on which to join the two datasets. For the crash data, this is easy.

```
> fullCrash$linker = paste(fullCrash$Date.Of.Loss.Year,
+                          fullCrash$Month.Of.Year,
+                          fullCrash$Day.Of.Week,
+                          fullCrash$Time.Category)
> head(fullCrash$linker)

[1] "2017 DECEMBER FRIDAY 00:00-02:59" "2017 FEBRUARY FRIDAY 00:00-02:59"
[3] "2017 APRIL FRIDAY 06:00-08:59"    "2017 JANUARY FRIDAY 06:00-08:59"
[5] "2017 JUNE FRIDAY 06:00-08:59"     "2017 OCTOBER FRIDAY 06:00-08:59"
```

For the weather data, we first collapse the hourly data to the same time periods as the crash data (00:00-02:59, 03:00-05:59, 06:00-08:59, 09:00-11:59, 12:00-14:59, 15:00-17:59, 18:00-20:59, 21:00-23:59):

```
> weatherTime = function(x){
+   #assigns the correct time category
+   if (x %in% c('00:00', '01:00', '02:00')){
+     return('00:00-02:59')
+   }
+   if (x %in% c('03:00', '04:00', '05:00')){
+     return('03:00-05:59')
+   }
+   if (x %in% c('06:00', '07:00', '08:00')){
+     return('06:00-08:59')
+   }
+   if (x %in% c('09:00', '10:00', '11:00')){
+     return('09:00-11:59')
+   }
+   if (x %in% c('12:00', '13:00', '14:00')){
+     return('12:00-14:59')
+   }
+   if (x %in% c('15:00', '16:00', '17:00')){
+     return('15:00-17:59')
+   }
+   if (x %in% c('18:00', '19:00', '20:00')){
+     return('18:00-20:59')
+   }
+   if (x %in% c('21:00', '22:00', '23:00')){
+     return('21:00-23:59')
+   }
+ }
> fullWeather$timeCategory = sapply(fullWeather$Time..LST., weatherTime)
> #we now can average the weather over these time periods
> timereducedWeather = c()
> j = 1
> for (i in seq(1, nrow(fullWeather), 3)){
+   #creating a whole new dataframe
+   timereducedWeather$linker[j] = fullWeather$linker[i]
+   timereducedWeather$Temp...C. = (fullWeather$Temp...C.[i] +
+     fullWeather$Temp...C.[i+1] + fullWeather$Temp...C.[i+2])/3
+   #...
+   j = j+1
+ }
> timereducedWeather = as.data.frame(timereducedWeather)
```

************FINISH THIS

Next, we need to get the day of the week. Then we can create the linker for the weather data:

```
> #weekday, in uppercase
> fullWeather$weekday = toupper(as.character(wday(as.Date(fullWeather$Date.Time..LST., tz='l
> #month
> fullWeather$monthName = toupper(as.character(month(as.Date(fullWeather$Date.Time..LST., tz
> #creating weather linker column
> fullWeather$linker = paste(fullWeather$Year,
+                            fullWeather$monthName,
+                            fullWeather$weekday,
+                            fullWeather$timeCategory)
```

Now, it is important to re-focus on what we want to do. We want to know the weather that was occurring during each crash (ie. for each row in the crash dataset). The only thing preventing us from doing this is that for each unique linker in the crash data, there are 4 (or 5) equivalent linkers in the weather dataset. In order to remove this ambiguity, we need to average the weather over the weather rows that have identical linkers.

```
> #getting indices of duplicates
>
```

************FINISH THIS

```
> #save(alldata, file = "../rda_files/all_data.rda")
```