# Final Project

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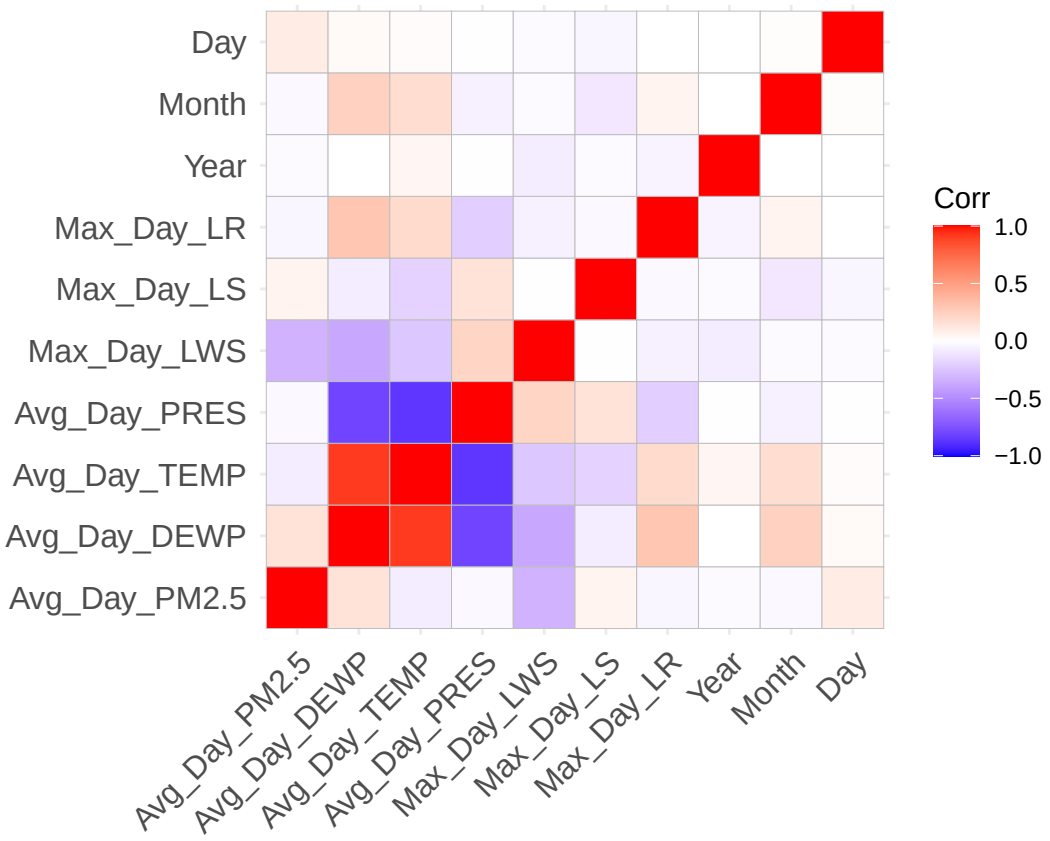
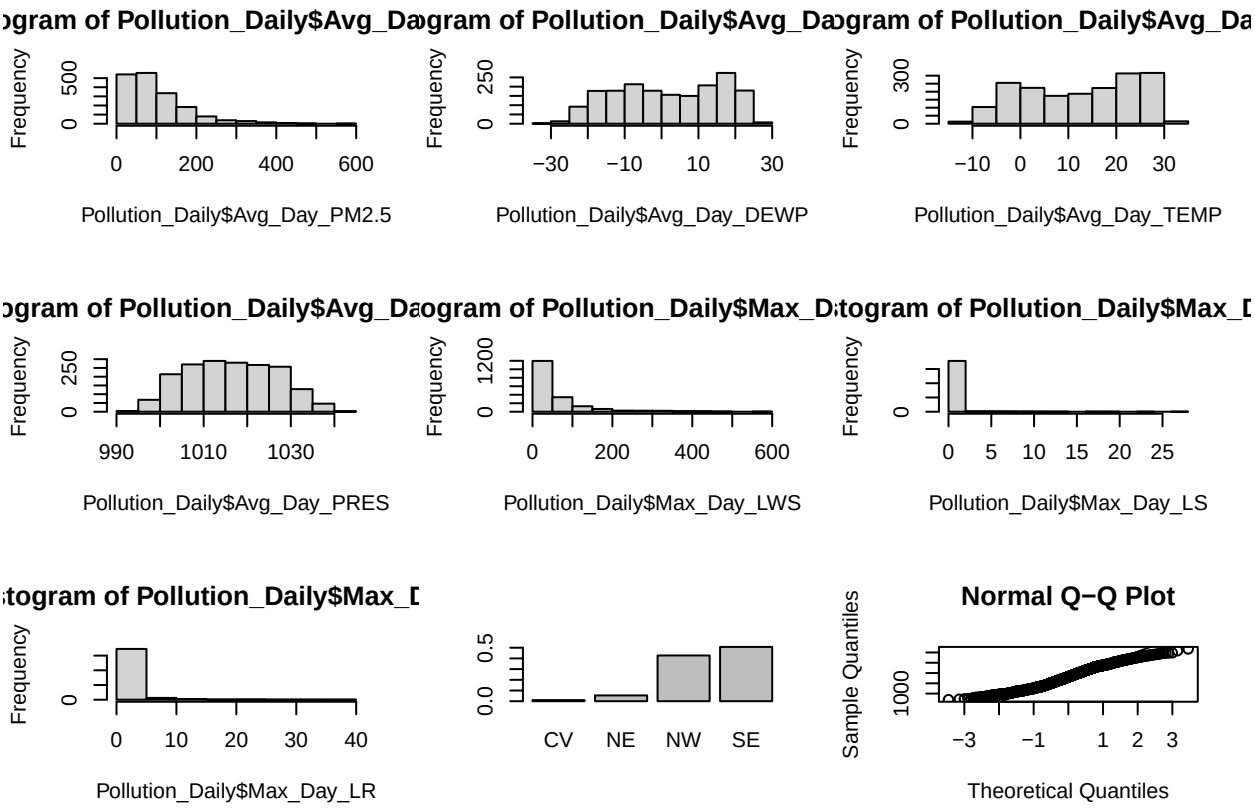
**Introduction**

**Exploratory Data Analysis**




Looking at a correlation heatmap we see aside from dewpoint precipitation and temperature there are no significant correlation in other variable




We can see that PM2.5 has an inverse distribution with values skewed towards low PM2.5 but many high values that go beyond the median

Temp and Dew point are highly related and so may not need to be included in the same model

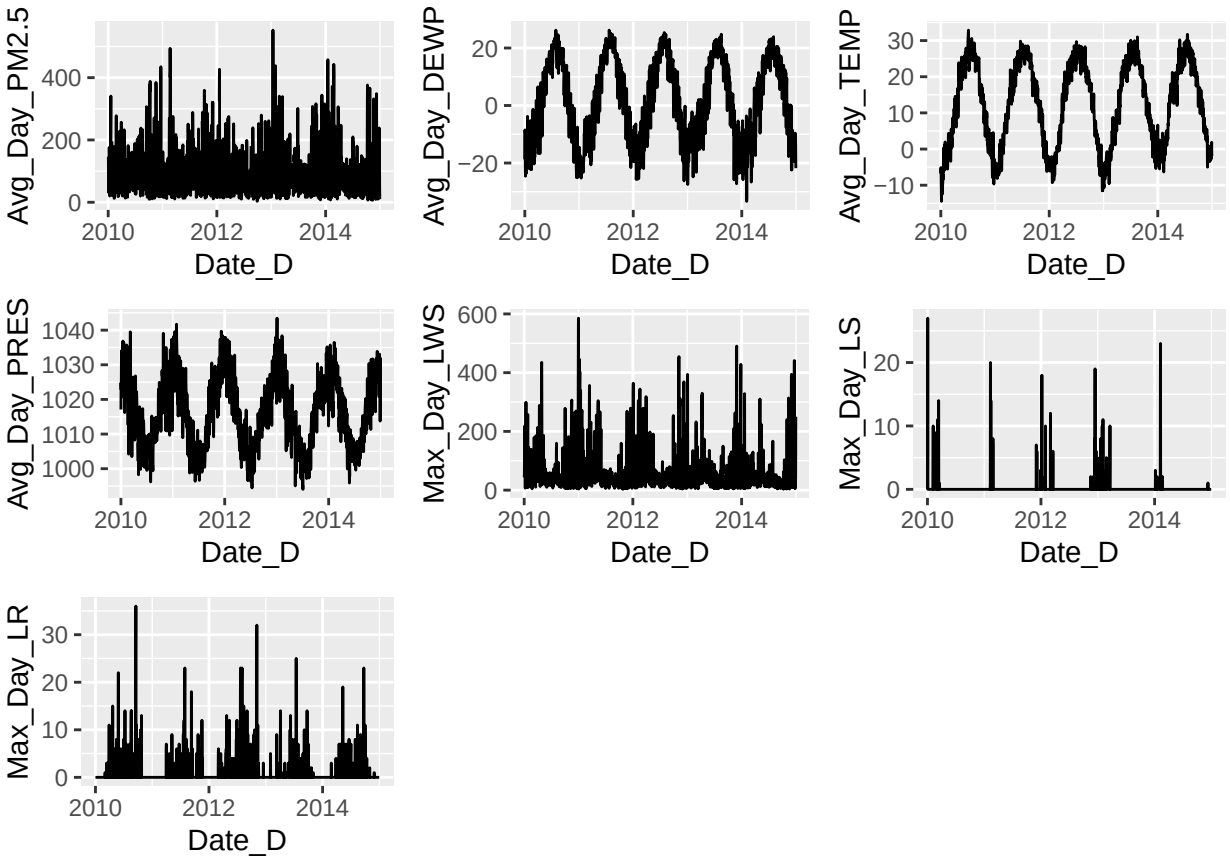
Precipitation looks like a bell curve but not normal as seen in the plot in 3,3

Wind speed is similar but not identical to PM2.5 in that it has an inverse distribution so it may be highly important in prediction

There is almost always not any snow in Beijing and the max is 27 for a day

Rain is also infrequent but there are times when there is a lot of rain

The most common direction is SE and NW while sometimes NE or CV

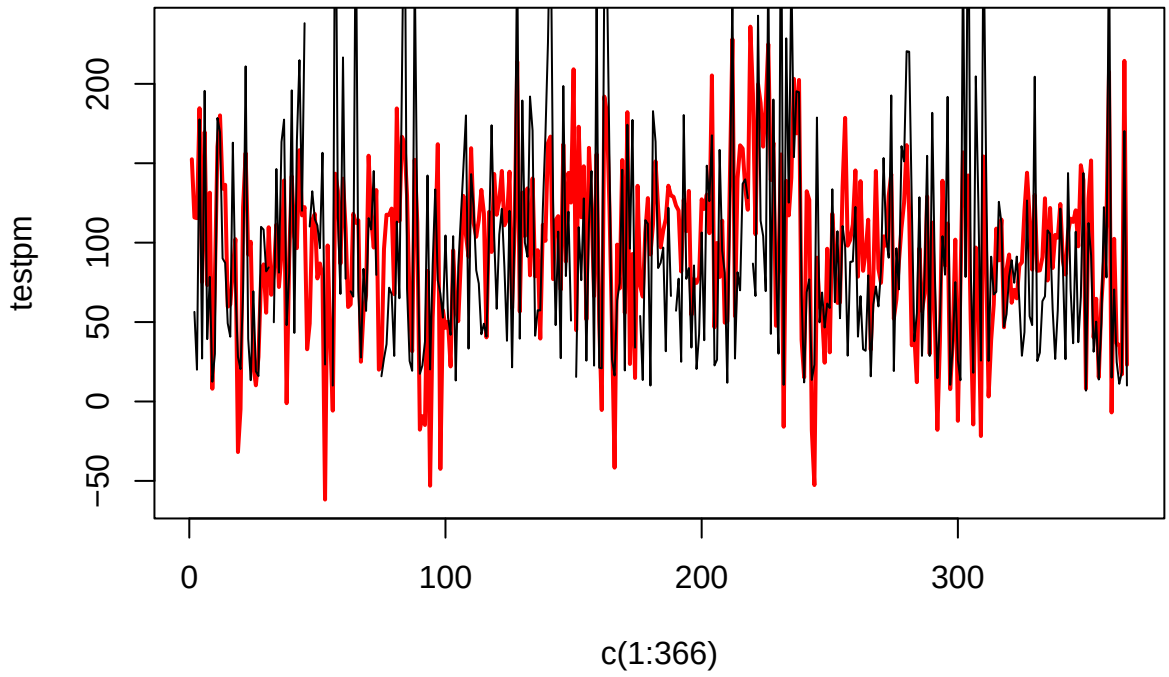



We see that pm2.5 varies in a slightly seasonal way in that peaks are near the start of year while dew point and temperature all peak in middle and precipitation peak during beginning with snow - wind speed also are near the time period

One thing that we can do also is based on common sense, we can predict that PM2.5 will not vary greatly with the day, month or year as we see that the pm2.5 time series is mostly random spikes with a mean of 200 about so let us see the day month and year

```
##
## Call:
## lm(formula = Avg_Day_PM2.5 ~ ., data = Pollution_Daily.train)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -159.14  -40.87  -10.04   29.32  321.50
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -4.615e+06  2.113e+06  -2.184 0.029089 *
## Date_D         -6.411e+00  2.935e+00  -2.184 0.029129 *
## Avg_Day_DEWP    7.189e+00  3.627e-01  19.821  < 2e-16 ***
## Avg_Day_TEMP   -1.081e+01  4.737e-01 -22.824  < 2e-16 ***
## Avg_Day_PRES   -2.504e+00  3.322e-01  -7.539 8.43e-14 ***
## Max_Day_LWS    -1.646e-01  2.730e-02  -6.030 2.08e-09 ***
## Max_Day_LS     -4.196e+00  1.016e+00  -4.132 3.81e-05 ***
## Max_Day_LR     -5.354e+00  6.344e-01  -8.440  < 2e-16 ***
## Max_Day_CBWDNE -7.925e+01  1.803e+01  -4.395 1.19e-05 ***
```

```
## Max_Day_CBWDNW -5.632e+01  1.677e+01  -3.359 0.000803 ***
## Max_Day_CBWDSE -5.075e+01  1.670e+01  -3.038 0.002424 **
## Year            2.344e+03  1.072e+03   2.186 0.028992 *
## Month           1.933e+02  8.935e+01   2.163 0.030699 *
## Day             7.128e+00  2.934e+00   2.430 0.015231 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 61.18 on 1420 degrees of freedom
##   (   26    )
## Multiple R-squared:  0.4062, Adjusted R-squared:  0.4007
## F-statistic: 74.71 on 13 and 1420 DF,  p-value: < 2.2e-16
```




```
## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å‘¨ä¸‰'³ö´í£º<e5>´úÌæÁËdot

## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å‘¨ä¸‰'³ö´í£º<91>´úÌæÁËdot

## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å‘¨ä¸‰'³ö´í£º<a8>´úÌæÁËdot

## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å‘¨ä¸‰'³ö´í£º<e4>´úÌæÁËdot
```

```
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## 'mbcsToSbcs'Àï×ª»»'å‘¨ä¸‰'³ö´í£º<89>´úÌæÁËdot

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## 'mbcsToSbcs'Àï×ª»»'å‘¨å››'³ö´í£º<9b>´úÌæÁËdot

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## 'mbcsToSbcs'Àï×ª»»'å‘¨å››'³ö´í£º<9b>´úÌæÁËdot

## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å‘¨äº"'³ö´í£º<e5>´úÌæÁËdot

## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å‘¨äº"'³ö´í£º<91>´úÌæÁËdot

## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å‘¨äº"'³ö´í£º<a8>´úÌæÁËdot
```
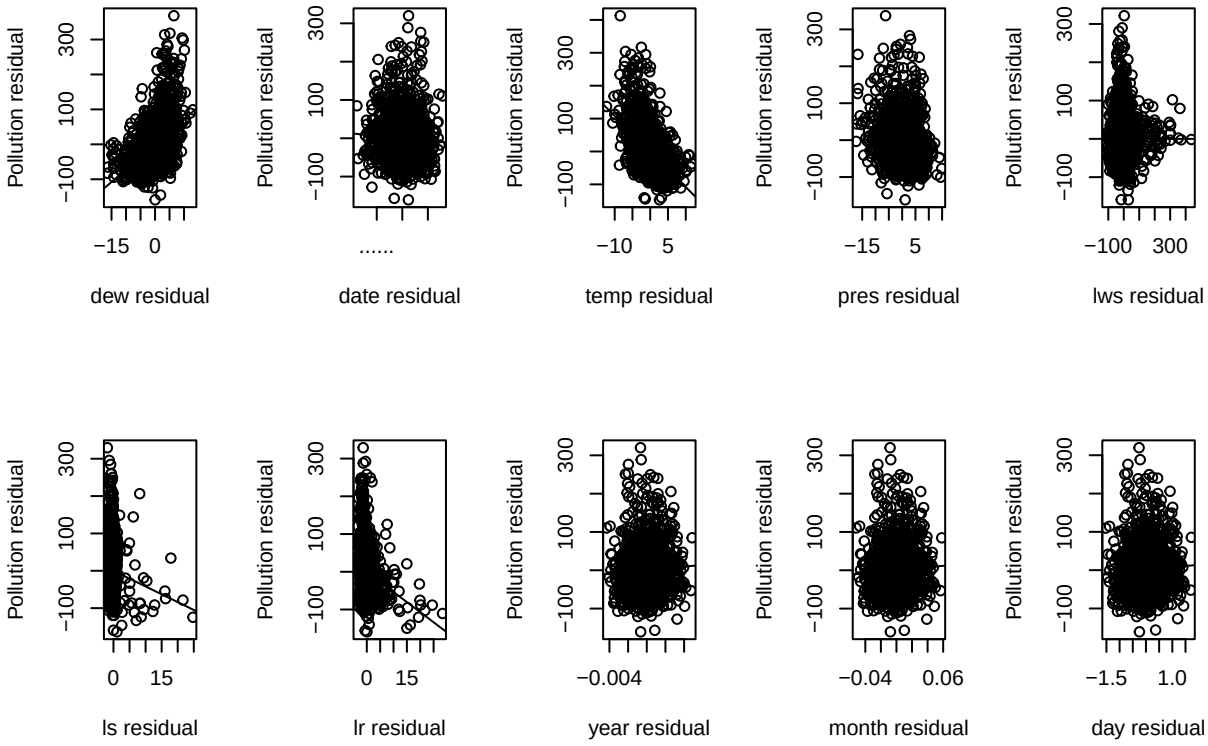
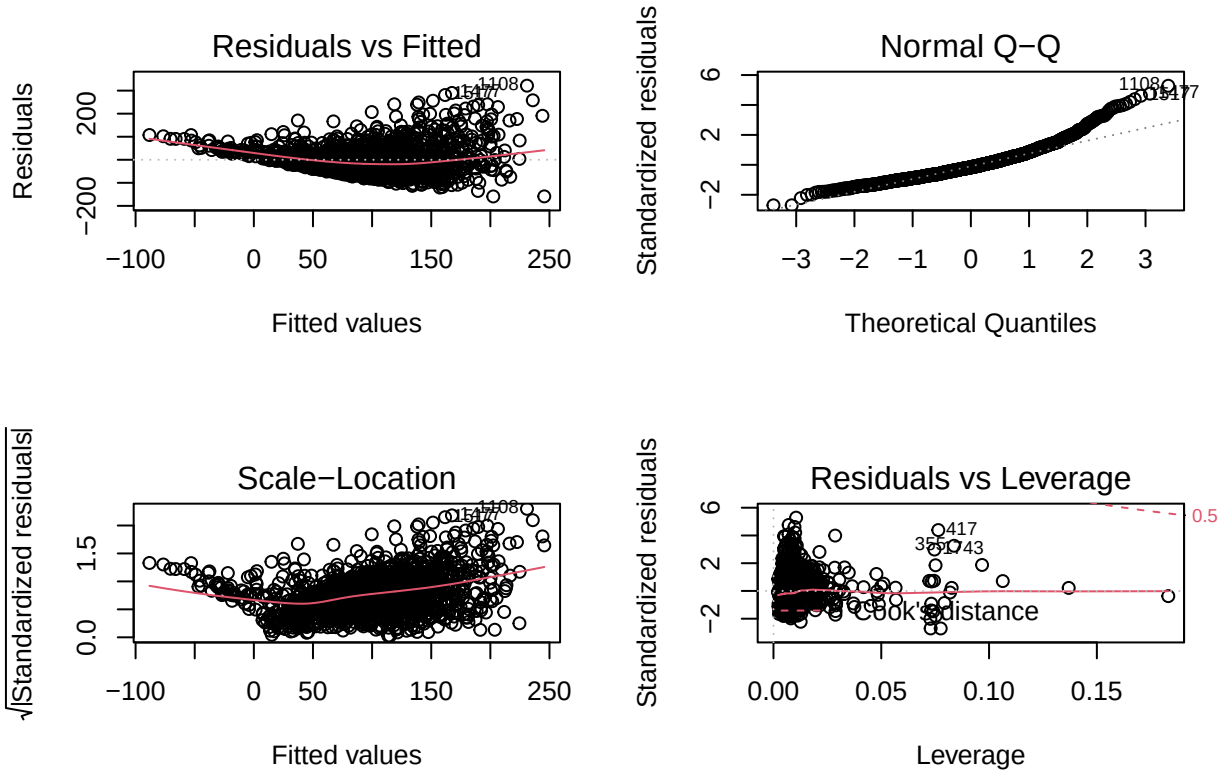

```
## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å'¨äº"'³ö´í£º<e4>´úÌæÁËdot

## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å'¨äº"'³ö´í£º<ba>´úÌæÁËdot

## Warning in axis(side, at = z, labels = labels, ...):
## 'mbcsToSbcs'Àï×ª»»'å'¨äº"'³ö´í£º<94>´úÌæÁËdot
```




After fitting a full model we see every single predictor is significant however R square is only 0.4 which suggests even though each coefficient is directionally correct the variation of response is not accurate

Doing a diagnostic of partial regression, There are no normally distributed partial regression and therefore the model is not linear




```
##    X.Homocedasticity. b...0.05 X.Normality. c...0.05 X.Uncorrelated.Errors.
## BP    Homocedasticity    FALSE    Normality    FALSE    Uncorrelated Errors
##    d...0.05
## BP    FALSE

## [1] b
## <0  > ( 0-  row.names)

##          3          9         35         38         42         43         45
## 0.18312369 0.01993036 0.02084889 0.02909985 0.02120462 0.02016636 0.01957692
##         59         60         65         67         73        112        118
## 0.02778616 0.02873632 0.02280094 0.04509421 0.05684717 0.02384532 0.02513578
##        119        148        212        250        260        264        297
## 0.02561832 0.04775556 0.02202594 0.01983728 0.07229409 0.02603939 0.03053323
##        347        355        364        365        372        375        404
## 0.02136388 0.08376838 0.02120852 0.04800714 0.03052893 0.02213194 0.02044289
##        409        417        423        465        470        575        608
## 0.04888755 0.07645773 0.02899026 0.02330743 0.01974735 0.02305260 0.02132032
##        618        659        664        702        717        725        734
## 0.03280053 0.07335589 0.07415222 0.02154804 0.01978184 0.02197048 0.02104081
##        737        758        760        792        808        894        918
## 0.08265230 0.07757221 0.02815190 0.04180265 0.02611715 0.02164709 0.02029063
##        933        934        939        943        944       1017       1018
## 0.02844410 0.04995945 0.01991536 0.03709670 0.04839376 0.07291344 0.07278236
##       1019       1039       1040       1044       1064       1065       1077
```

```
## 0.07320367 0.10636050 0.03250507 0.07316761 0.01984485 0.01984594 0.02111622
##       1079       1098       1099       1119       1125       1128       1129
## 0.09675365 0.02018495 0.02925196 0.02134172 0.02862577 0.02008693 0.01977021
##       1130       1175       1183       1292       1362       1370       1375
## 0.03647560 0.02881126 0.02004238 0.05664320 0.02051762 0.02092169 0.07448111
##       1428       1429       1434       1449       1454       1457       1463
## 0.03298086 0.03492779 0.01996232 0.01966219 0.07518163 0.02553009 0.07930188
##       1485       1499       1500       1555       1592       1654       1677
## 0.02054096 0.08190632 0.13694349 0.02033825 0.03754080 0.01992540 0.02158615
##       1703       1727       1743       1772       1792       1797
## 0.02238124 0.05105359 0.07468200 0.07520319 0.01981613 0.02760467
```

```
##             b d        c
## 417  4.416884 > 4.152357
## 1108 5.333325 > 4.152357
## 1477 4.792634 > 4.152357
## 1517 4.647787 > 4.152357
## 1518 4.233889 > 4.152357
```

```
## Analysis of Variance Table
##
## Response: Avg_Day_PM2.5
##                Df  Sum Sq Mean Sq  F value    Pr(>F)
## Date_D          1    1339    1339   0.3577 0.5499001
## Avg_Day_DEWP    1  188302  188302  50.3013 2.073e-12 ***
## Avg_Day_TEMP    1 2395516 2395516 639.9164 < 2.2e-16 ***
## Avg_Day_PRES    1  244962  244962  65.4370 1.275e-15 ***
## Max_Day_LWS     1  232063  232063  61.9912 6.801e-15 ***
## Max_Day_LS      1   38629   38629  10.3189 0.0013463 **
## Max_Day_LR      1  293980  293980  78.5312 < 2.2e-16 ***
## Max_Day_CBWD    3  110235   36745   9.8158 2.076e-06 ***
## Year            1   44499   44499  11.8871 0.0005818 ***
## Month           1   64290   64290  17.1739 3.612e-05 ***
## Day             1   22101   22101   5.9038 0.0152314 *
## Residuals    1420 5315745    3743
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```