STAT 652 Assignment 1

Dhruv Patel

13/10/2021

Lecture 5 Application
We will now do variable selection with these five variables
1. Use all-subsets regression.

```
rm(list=ls(all=TRUE))
data = na.omit(airquality[,1:4])

data$TWcp = data$Temp*data$Wind
data$TWrat = data$Temp/data$Wind

filter_data = model.matrix(Ozone ~.,data= data)
head(filter_data)
```

```
##   (Intercept) Solar.R Wind Temp  TWcp    TWrat
## 1           1     190  7.4   67 495.8 9.054054
## 2           1     118  8.0   72 576.0 9.000000
## 3           1     149 12.6   74 932.4 5.873016
## 4           1     313 11.5   62 713.0 5.391304
## 7           1     299  8.6   65 559.0 7.558140
## 8           1      99 13.8   59 814.2 4.275362
```

```
library(leaps)
allsub <- regsubsets(x=filter_data,
                     y=data$Ozone, intercept = F)

info.subsets = summary(allsub)
seq.subsets = info.subsets$which
vars.seq.subsets.raw = apply(seq.subsets, 1, function(W){
  vars.list = names(W)[W]
  output = paste0(vars.list, collapse = ", ")})
```

(a) Report the variables in the best model of each size.

```
print(vars.seq.subsets.raw)
```

```
##                                         1
##                                   "TWrat"
##                                         2
##                             "Solar.R, TWrat"
```

```
##                                                3
##                     "(Intercept), Temp, TWrat"
##                                                4
##             "(Intercept), Solar.R, Temp, TWrat"
##                                                5
##        "(Intercept), Solar.R, Wind, Temp, TWcp"
##                                                6
## "(Intercept), Solar.R, Wind, Temp, TWcp, TWrat"
```

(b) Compute BIC on each of these models and report the BIC values for the models.
Answer:

```
print(info.subsets$bic)
```

```
## [1] -185.2244 -189.0768 -204.1878 -207.1195 -204.6274 -202.8590
```

(c) Identify the best model. What variables are in it?
Answer: The best model is (Intercept),Solar.R,Temp,TWrat since its has minimum BIC value i.e. -207.1195

```
print(min(info.subsets$bic))
```

```
## [1] -207.1195
```

2. Use the hybrid stepwise algorithm that is the default in the step() function. Report the model that it chooses as "best."
Answer: The best model according to stepwise algorithm is TWrat + Temp + Solar.R.

```
data$TWcp = data$Temp*data$Wind
data$TWrat = data$Temp/data$Wind
head(data)
```

```
##   Ozone Solar.R Wind Temp  TWcp    TWrat
## 1    41     190  7.4   67 495.8 9.054054
## 2    36     118  8.0   72 576.0 9.000000
## 3    12     149 12.6   74 932.4 5.873016
## 4    18     313 11.5   62 713.0 5.391304
## 7    23     299  8.6   65 559.0 7.558140
## 8    19      99 13.8   59 814.2 4.275362
```

```
rows = nrow(data)

initial <- lm(data=data, formula=Ozone~ 1)
final <- lm(data=data, formula=Ozone~Solar.R+Wind+Temp+TWcp+TWrat)
step <- step(object=initial, scope=list(upper=final), k = log(rows))
```

```
## Start:  AIC=781.78
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
```

```
## + TWrat    1     64323  57479 703.13
## + Temp     1     59434  62367 712.19
## + Wind     1     45694  76108 734.29
## + TWcp     1     24804  96998 761.21
## + Solar.R  1     14780 107022 772.13
## <none>                 121802 781.78
##
## Step:  AIC=703.13
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     12916  44563 679.59
## + Solar.R  1      6542  50938 694.43
## <none>                  57479 703.13
## + TWcp     1      1256  56223 705.39
## + Wind     1       332  57147 707.20
## - TWrat    1     64323 121802 781.78
##
## Step:  AIC=679.59
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2964.5 41599 676.66
## <none>                 44563 679.59
## + TWcp     1     434.8 44128 683.21
## + Wind     1     222.1 44341 683.74
## - Temp     1   12916.3 57479 703.13
## - TWrat    1   17804.4 62367 712.19
##
## Step:  AIC=676.66
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                 41599 676.66
## - Solar.R  1    2964.5 44563 679.59
## + TWcp     1     508.1 41090 680.00
## + Wind     1     248.0 41351 680.70
## - Temp     1    9339.1 50938 694.43
## - TWrat    1   18045.8 59644 711.94
```

```
summary(step)
```

```
##
## Call:
## lm(formula = Ozone ~ TWrat + Temp + Solar.R, data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -56.168 -12.102  -4.424  11.403  77.471
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -93.30421   17.28283  -5.399 4.08e-07 ***
## TWrat         2.86326    0.42026   6.813 5.82e-10 ***
```

```
## Temp          1.25231    0.25551   4.901 3.41e-06 ***
## Solar.R       0.05960    0.02158   2.761  0.00678 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 19.72 on 107 degrees of freedom
## Multiple R-squared:  0.6585, Adjusted R-squared:  0.6489
## F-statistic: 68.77 on 3 and 107 DF,  p-value: < 2.2e-16
```

3. Use 10-fold CV to estimate the MSPE for the stepwise model selection process. That is,

(a) Set the seed to 2928893 before running the sample.int() function.

(b) Create 10 folds

(c) Run step() on each training set

(d) Find the best model, and compute the prediction error on it

(e) Report the separate MSPEs from each fold, MSP Ev, v = 1, . . . , 10 and the MSPE for the full data. Answers:

```
set.seed(2928893)
rows = nrow(data)
V=10
folds = floor((sample.int(rows)-1)*V/rows) + 1
mat_CV_L5 = matrix(NA, nrow=V, ncol=1)

for(v in 1:V){

  initial <- lm(data=data[folds != v,], formula=Ozone~ 1)
  final <- lm(data=data[folds != v,], formula=Ozone~Solar.R+Wind+Temp+TWcp+TWrat)
  rows = nrow(data[folds != v,])
  step <- step(object=initial, scope=list(upper=final), k = log(rows))

  pred = predict(step,newdata=data[folds==v,])
  summary(pred)
  mat_CV_L5[v,1] = mean((data[folds==v,"Ozone"] - pred)^2)
}
```

```
## Start:  AIC=702.68
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     60815  53471 632.08
## + Temp     1     56213  58073 640.25
## + Wind     1     43966  70320 659.19
## + TWcp     1     25493  88793 682.29
## + Solar.R  1     12398 101888 695.90
## <none>                 114286 702.68
##
## Step:  AIC=632.08
```

```
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     11732  41738 612.15
## + Solar.R  1      5995  47476 624.90
## <none>                   53471 632.08
## + TWcp     1       860  52610 635.06
## + Wind     1       430  53041 635.87
## - TWrat    1     60815 114286 702.68
##
## Step:  AIC=612.15
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2335.5 39403 611.04
## <none>                  41738 612.15
## + TWcp     1     329.7 41409 615.96
## + Wind     1     146.4 41592 616.39
## - Temp     1   11732.4 53471 632.08
## - TWrat    1   16334.3 58073 640.25
##
## Step:  AIC=611.04
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                  39403 611.04
## - Solar.R  1    2335.5 41738 612.15
## + TWcp     1     461.4 38942 614.47
## + Wind     1     199.8 39203 615.13
## - Temp     1    8073.2 47476 624.90
## - TWrat    1   17102.6 56506 642.14
## Start:  AIC=703.03
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     59974  47975 626.54
## + Temp     1     51641  56308 642.55
## + Wind     1     38512  69437 663.51
## + TWcp     1     20036  87913 687.10
## + Solar.R  1     12164  95785 695.68
## <none>                 107949 703.03
##
## Step:  AIC=626.54
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1      8751  39224 611.00
## + Solar.R  1      5464  42511 619.05
## + TWcp     1      3069  44906 624.53
## <none>                  47975 626.54
## + Wind     1       178  47797 630.77
## - TWrat    1     59974 107949 703.03
##
## Step:  AIC=611
```

```
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2844.4 36380 608.08
## <none>                 39224 611.00
## + Wind     1      40.7 39183 615.50
## + TWcp     1       4.1 39220 615.60
## - Temp     1    8750.6 47975 626.54
## - TWrat    1   17084.4 56308 642.55
##
## Step:  AIC=608.08
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                 36380 608.08
## - Solar.R  1    2844.4 39224 611.00
## + Wind     1      10.6 36369 612.66
## + TWcp     1       4.5 36375 612.67
## - Temp     1    6131.2 42511 619.05
## - TWrat    1   17501.0 53881 642.75
## Start:  AIC=697.92
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     52346  50221 631.11
## + Temp     1     51128  51439 633.51
## + Wind     1     35862  66705 659.50
## + TWcp     1     18152  84415 683.04
## + Solar.R  1     13264  89303 688.67
## <none>                 102567 697.92
##
## Step:  AIC=631.11
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     12215  38006 607.85
## + Solar.R  1      5921  44300 623.17
## <none>                  50221 631.11
## + TWcp     1      1695  48526 632.28
## + Wind     1       155  50066 635.41
## - TWrat    1     52346 102567 697.92
##
## Step:  AIC=607.85
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2256.7 35749 606.33
## <none>                 38006 607.85
## + TWcp     1     111.4 37894 612.16
## + Wind     1      28.3 37978 612.38
## - Temp     1   12215.3 50221 631.11
## - TWrat    1   13432.6 51439 633.51
##
## Step:  AIC=606.33
```

```
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                  35749 606.33
## - Solar.R  1    2256.7 38006 607.85
## + TWcp     1     178.1 35571 610.44
## + Wind     1      50.5 35699 610.80
## - Temp     1    8550.6 44300 623.17
## - TWrat    1   13786.9 49536 634.34
## Start:  AIC=700.65
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     54886  50521 631.71
## + Temp     1     47981  57426 644.52
## + Wind     1     37187  68220 661.74
## + TWcp     1     19016  86390 685.36
## + Solar.R  1     14196  91210 690.79
## <none>                 105407 700.65
##
## Step:  AIC=631.71
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     10331  40190 613.44
## + Solar.R  1      6711  43810 622.06
## <none>                  50521 631.71
## + TWcp     1      1602  48919 633.09
## + Wind     1        81  50440 636.15
## - TWrat    1     54886 105407 700.65
##
## Step:  AIC=613.44
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    3642.8 36548 608.54
## <none>                 40190 613.44
## + TWcp     1     180.4 40010 617.59
## + Wind     1      85.2 40105 617.83
## - Temp     1   10330.5 50521 631.71
## - TWrat    1   17235.4 57426 644.52
##
## Step:  AIC=608.54
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                 36548 608.54
## + TWcp     1     242.7 36305 612.48
## + Wind     1     123.9 36424 612.81
## - Solar.R  1    3642.8 40190 613.44
## - Temp     1    7262.2 43810 622.06
## - TWrat    1   17199.5 53747 642.50
## Start:  AIC=690.95
## Ozone ~ 1
```

```
##
##           Df Sum of Sq   RSS    AIC
## + Temp     1     51807 43862 617.57
## + TWrat    1     48459 47210 624.93
## + Wind     1     35136 60533 649.79
## + TWcp     1     17692 77977 675.11
## + Solar.R  1     12912 82757 681.06
## <none>                 95669 690.95
##
## Step:  AIC=617.57
## Ozone ~ Temp
##
##           Df Sum of Sq   RSS    AIC
## + TWrat    1     10632 33230 594.42
## + TWcp     1      9593 34269 597.50
## + Wind     1      7685 36176 602.91
## <none>                 43862 617.57
## + Solar.R  1      1638 42224 618.37
## - Temp     1     51807 95669 690.95
##
## Step:  AIC=594.42
## Ozone ~ Temp + TWrat
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2041.6 31188 592.68
## <none>                 33230 594.42
## + TWcp     1     787.7 32442 596.63
## + Wind     1     400.5 32829 597.81
## - TWrat    1   10631.5 43862 617.57
## - Temp     1   13980.0 47210 624.93
##
## Step:  AIC=592.68
## Ozone ~ Temp + TWrat + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                 31188 592.68
## - Solar.R  1    2041.6 33230 594.42
## + TWcp     1     828.4 30360 594.60
## + Wind     1     402.1 30786 595.99
## - Temp     1    9954.5 41143 615.78
## - TWrat    1   11035.4 42224 618.37
## Start:  AIC=710.17
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     60836  55107 640.40
## + Temp     1     57604  58339 646.10
## + Wind     1     43129  72814 668.26
## + TWcp     1     23462  92481 692.17
## + Solar.R  1     13584 102359 702.32
## <none>                 115943 710.17
##
## Step:  AIC=640.4
## Ozone ~ TWrat
```

```
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     13828  41279 616.11
## + Solar.R  1      6051  49056 633.37
## <none>                   55107 640.40
## + TWcp     1      1218  53889 642.77
## + Wind     1       378  54729 644.31
## - TWrat    1     60836 115943 710.17
##
## Step:  AIC=616.11
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2736.2 38543 613.86
## <none>                  41279 616.11
## + TWcp     1     519.9 40759 619.45
## + Wind     1     296.5 40983 619.99
## - Temp     1   13827.9 55107 640.40
## - TWrat    1   17059.7 58339 646.10
##
## Step:  AIC=613.86
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                  38543 613.86
## - Solar.R  1    2736.2 41279 616.11
## + TWcp     1     502.6 38041 617.15
## + Wind     1     257.0 38286 617.79
## - Temp     1   10513.2 49056 633.37
## - TWrat    1   17085.3 55628 645.94
## Start:  AIC=710.48
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     67132  49163 628.98
## + Temp     1     55714  60581 649.87
## + Wind     1     46340  69955 664.25
## + TWcp     1     23729  92565 692.26
## + Solar.R  1     15806 100488 700.47
## <none>                  116294 710.48
##
## Step:  AIC=628.98
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     10889  38273 608.55
## + Solar.R  1      5659  43504 621.36
## <none>                   49163 628.98
## + TWcp     1      1535  47628 630.42
## + Wind     1       164  48999 633.25
## - TWrat    1     67132 116294 710.48
##
## Step:  AIC=608.55
## Ozone ~ TWrat + Temp
```

```
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2463.7 35810 606.50
## <none>                 38273 608.55
## + TWcp     1     354.0 37919 612.23
## + Wind     1     183.2 38090 612.67
## - Temp     1   10889.4 49163 628.98
## - TWrat    1   22307.2 60581 649.87
##
## Step:  AIC=606.5
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                 35810 606.50
## - Solar.R  1    2463.7 38273 608.55
## + TWcp     1     414.9 35395 609.94
## + Wind     1     203.8 35606 610.54
## - Temp     1    7694.2 43504 621.36
## - TWrat    1   22096.6 57906 649.96
## Start:  AIC=710.68
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     63520  53013 636.52
## + Temp     1     56525  60007 648.92
## + Wind     1     48353  68180 661.68
## + TWcp     1     29046  87487 686.62
## + Solar.R  1     13418 103115 703.05
## <none>                 116533 710.68
##
## Step:  AIC=636.52
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     10768  42245 618.42
## + Solar.R  1      4493  48519 632.27
## <none>                  53013 636.52
## + Wind     1       936  52076 639.35
## + TWcp     1       348  52665 640.47
## - TWrat    1     63520 116533 710.68
##
## Step:  AIC=618.42
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2356.9 39888 617.29
## <none>                 42245 618.42
## + TWcp     1     837.1 41407 621.03
## + Wind     1     508.4 41736 621.82
## - Temp     1   10768.2 53013 636.52
## - TWrat    1   17762.9 60007 648.92
##
## Step:  AIC=617.29
## Ozone ~ TWrat + Temp + Solar.R
```

```
##
##           Df Sum of Sq   RSS    AIC
## <none>                  39888 617.29
## - Solar.R  1    2356.9 42245 618.42
## + TWcp     1     730.7 39157 620.04
## + Wind     1     405.2 39483 620.87
## - Temp     1    8631.7 48519 632.27
## - TWrat    1   17159.3 57047 648.46
## Start:  AIC=711.46
## Ozone ~ 1
##
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     61399  56049 642.09
## + Temp     1     57702  59745 648.48
## + Wind     1     45089  72359 667.63
## + TWcp     1     25377  92070 691.72
## + Solar.R  1     14633 102814 702.76
## <none>                  117448 711.46
##
## Step:  AIC=642.09
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     12664  43385 621.08
## + Solar.R  1      7059  48989 633.23
## <none>                   56049 642.09
## + TWcp     1       914  55135 645.05
## + Wind     1       523  55526 645.76
## - TWrat    1     61399 117448 711.46
##
## Step:  AIC=621.08
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    3464.7 39920 617.37
## <none>                  43385 621.08
## + TWcp     1     517.6 42867 624.49
## + Wind     1     293.0 43092 625.01
## - Temp     1   12664.1 56049 642.09
## - TWrat    1   16360.6 59745 648.48
##
## Step:  AIC=617.37
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                  39920 617.37
## + TWcp     1     635.7 39284 620.37
## - Solar.R  1    3464.7 43385 621.08
## + Wind     1     347.6 39572 621.10
## - Temp     1    9069.4 48989 633.23
## - TWrat    1   16703.5 56624 647.72
## Start:  AIC=698.44
## Ozone ~ 1
##
```

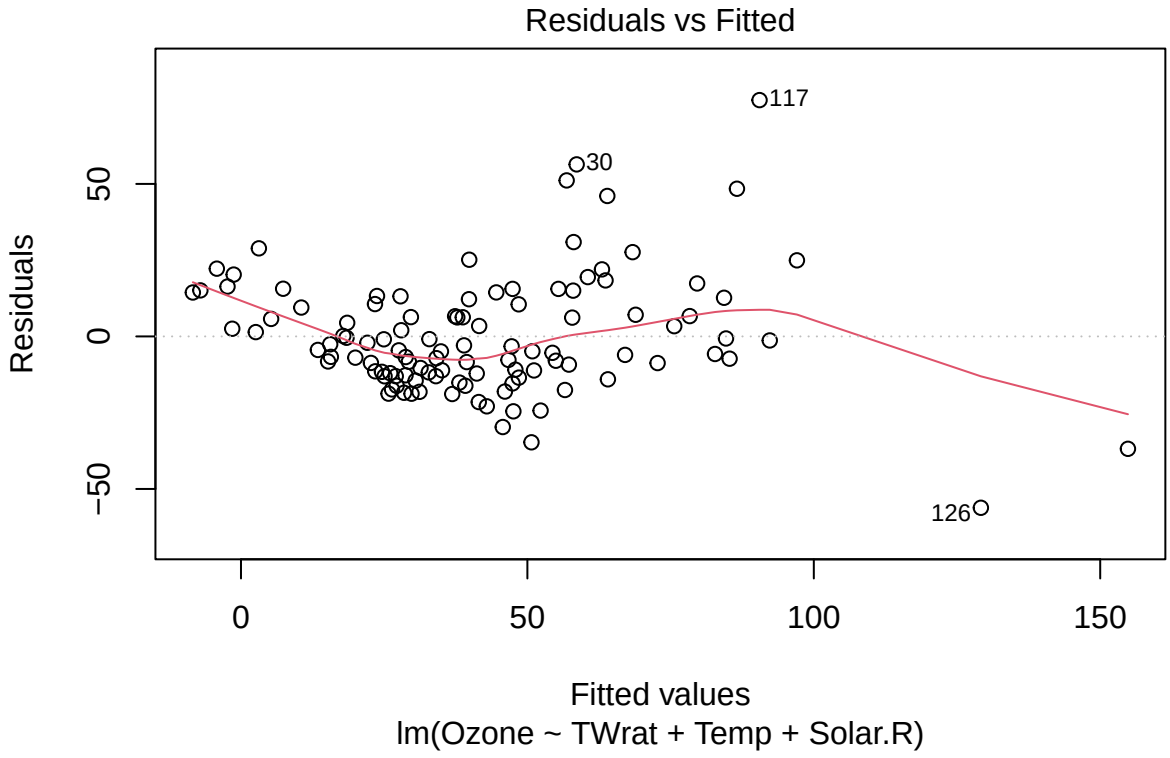
```
##           Df Sum of Sq    RSS    AIC
## + TWrat    1     52732  50375 631.42
## + Temp     1     48457  54650 639.56
## + Wind     1     38890  64217 655.70
## + TWcp     1     22477  80630 678.46
## + Solar.R  1     10598  92509 692.20
## <none>                 103107 698.44
##
## Step:  AIC=631.42
## Ozone ~ TWrat
##
##           Df Sum of Sq    RSS    AIC
## + Temp     1     10214  40161 613.36
## + Solar.R  1      5153  45222 625.23
## <none>                  50375 631.42
## + Wind     1       556  49818 634.91
## + TWcp     1       500  49875 635.03
## - TWrat    1     52732 103107 698.44
##
## Step:  AIC=613.36
## Ozone ~ TWrat + Temp
##
##           Df Sum of Sq   RSS    AIC
## + Solar.R  1    2506.3 37655 611.53
## <none>                 40161 613.36
## + TWcp     1     692.5 39469 616.23
## + Wind     1     461.0 39700 616.81
## - Temp     1   10213.6 50375 631.42
## - TWrat    1   14489.1 54650 639.56
##
## Step:  AIC=611.53
## Ozone ~ TWrat + Temp + Solar.R
##
##           Df Sum of Sq   RSS    AIC
## <none>                 37655 611.53
## - Solar.R  1    2506.3 40161 613.36
## + TWcp     1     753.1 36902 614.11
## + Wind     1     487.5 37167 614.83
## - Temp     1    7567.3 45222 625.23
## - TWrat    1   14825.1 52480 640.12
```

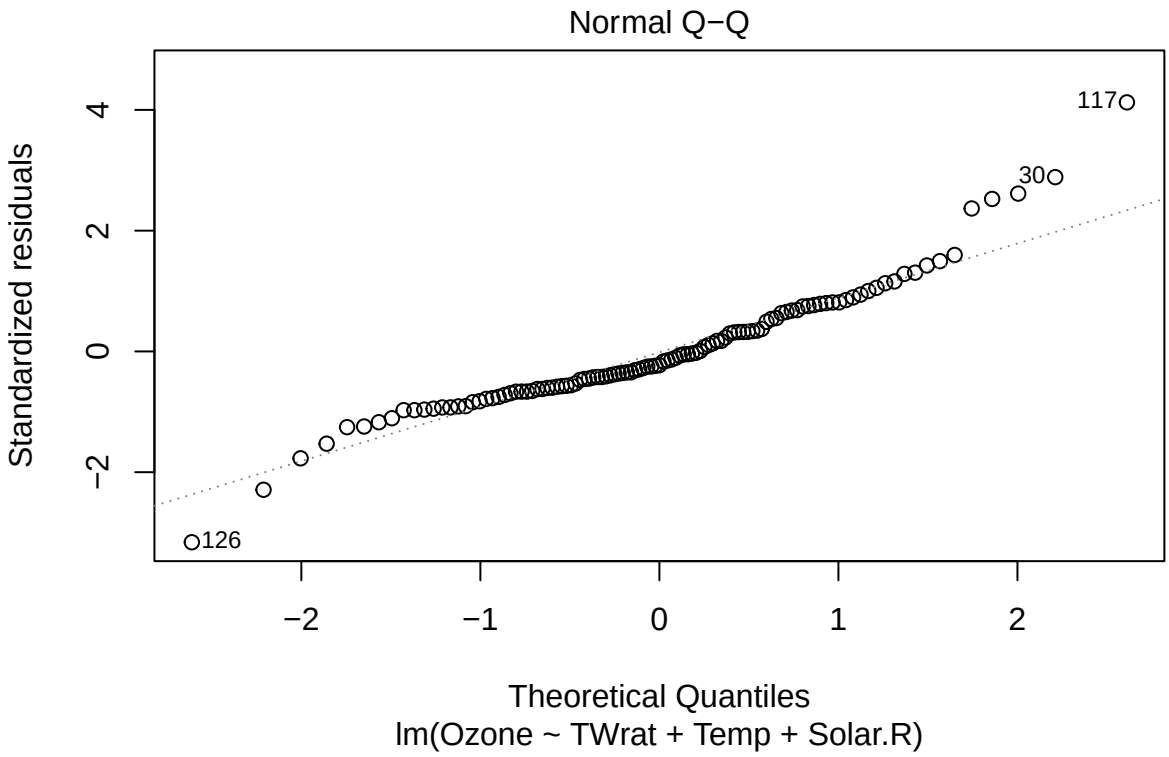
```
lm_best = lm(Ozone ~ TWrat + Temp + Solar.R, data = data)
summary(lm_best)
```

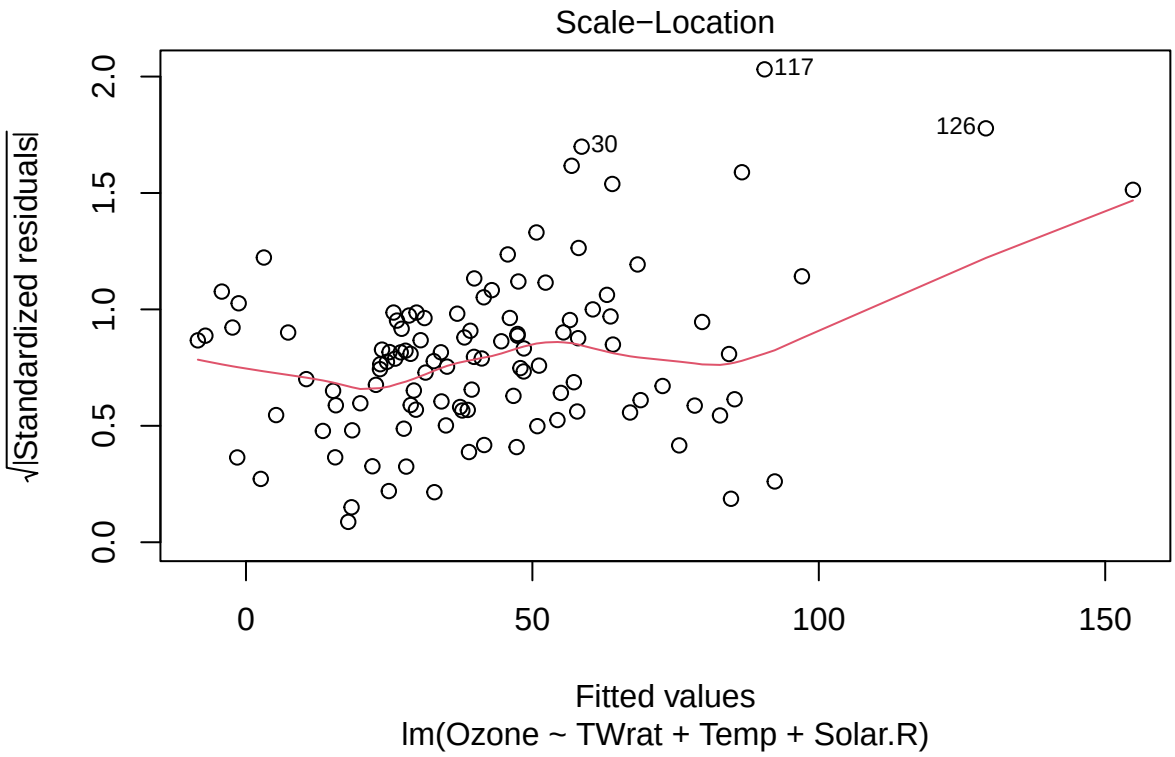
```
##
## Call:
## lm(formula = Ozone ~ TWrat + Temp + Solar.R, data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -56.168 -12.102  -4.424  11.403  77.471
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
```

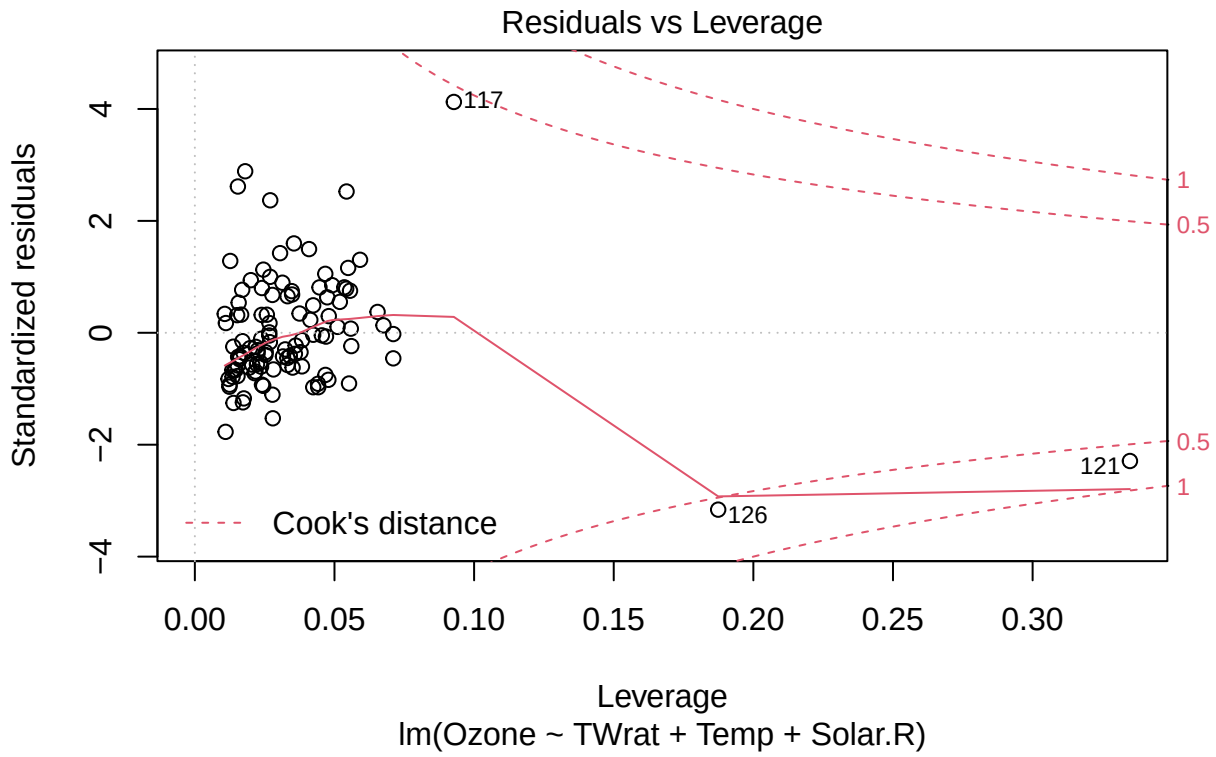
```
## (Intercept) -93.30421   17.28283  -5.399 4.08e-07 ***
## TWrat         2.86326    0.42026   6.813 5.82e-10 ***
## Temp          1.25231    0.25551   4.901 3.41e-06 ***
## Solar.R       0.05960    0.02158   2.761  0.00678 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 19.72 on 107 degrees of freedom
## Multiple R-squared:  0.6585, Adjusted R-squared:  0.6489
## F-statistic: 68.77 on 3 and 107 DF,  p-value: < 2.2e-16
```

```
plot(lm_best)
```




Normal Q−Q
Standardized residuals
Theoretical Quantiles
lm(Ozone ~ TWrat + Temp + Solar.R)
117
30
126
−2
0
2
4
−2
−1
0
1
2


Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
117
126
30
0
50
100
150
Fitted values
lm(Ozone ~ TWrat + Temp + Solar.R)




```
colnames(mat_CV_L5) = c('Each fold MPSE')
mat_CV_L5
```

```
##       Each fold MPSE
##  [1,]       183.4986
##  [2,]       574.0699
##  [3,]       558.8930
##  [4,]       475.7123
##  [5,]      1011.1412
##  [6,]       291.4034
##  [7,]       665.8734
##  [8,]       157.0123
##  [9,]       163.6635
## [10,]       370.1384
```

```
mean(mat_CV_L5)
```

```
## [1] 445.1406
```