MVA_Project3.R

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```r
###### Assignment 5 ##############
## Applying Cluster Analysis

#Getting working directory
getwd()
```

```
## [1] "/Users/thindprateek/Desktop/Multivariate Analysis"
```

```r
#Setting directory to load data set
setwd("/Users/thindprateek/Desktop/Multivariate Analysis")

#Reading the data into a data frame
#df <- read.csv(file = 'US_Acc_June20.csv')
num <- read.csv(file = 'num.csv')
# Performing clustering on the first 500 records for now to achieve easy and quick results and test the
num<-num[1:500,]
attach(num)
# Printing first few columns of data set for inference
#head(df)

## Setting random seed to shuffle data before splitting
set.seed(23)

#Checking number of rows
#rows<-sample(nrow(df))

#Shuffling the data
#mva<-df[rows,]

#Taking the required number of instances from the shuffled data to reduce any biases
#mva<-mva[950000:1000000,]

#Checking the structure of the data set
#str(mva)

# Checking the number of rows and columns in the current uncleaned dataset
#ncol(mva)
#nrow(mva)

# Printing all the column names to find and filter the relevant and irrelevant attributes
#names<-names(mva)
```

```r
#names

## DATA CLEANING ##

#Dropping the surplus attributes which do not contribute to the analysis
#mva <- mva[-c(1:3,7:10,13,14,19,21:23,33,47:49)]

#Checking for any null values in the present data set
# is.na(mva[,])

#Checking which rows have all the values filled and complete
# complete.cases(mva)

#Making a new dataframe with only the rows that have complete information and all values filled
#Mva<-na.omit(mva)
#Mva<-Mva[!(is.na(Mva$Sunrise_Sunset) | Mva$Sunrise_Sunset==""), ]
#Mva<- Mva[complete.cases(Mva),]
#Verifying for missing values in the new dataframe
#complete.cases(Mva)
#unique(Mva$Sunrise_Sunset)
#Checking the number of rows and columns in the new CLEANED dataframe
#ncol(Mva)
#nrow(Mva)

# Creating new dataframe with only the numerical attributes to perform statistical functions
#num<-Mva[,c(1,4,11:15,17,18)]
#write.csv(num,"/Users/thindprateek/Desktop/Multivariate Analysis/num.csv", row.names = FALSE)
#Scaling the dataset before applying clusturing algorithms

nrow(num)
```

```
## [1] 500
```

```r
ncol(num)
```

```
## [1] 9
```

```r
###### Checking to see for any correlation that might interefere with the data #######
cor(num)
```

```
##                    Severity Distance.mi. Temperature.F. Wind_Chill.F.
## Severity         1.00000000  0.060325232    -0.026274516   -0.03165259
## Distance.mi.     0.06032523  1.000000000    -0.010229758   -0.01679232
## Temperature.F.  -0.02627452 -0.010229758     1.000000000    0.99372259
## Wind_Chill.F.   -0.03165259 -0.016792324     0.993722592    1.00000000
## Humidity...      0.08687654  0.004473866    -0.452662114   -0.43537980
## Pressure.in.     0.06567115 -0.008218439     0.055390478    0.05040739
## Visibility.mi.  -0.01784787 -0.041477419     0.256766004    0.26208308
## Wind_Speed.mph. -0.06205678  0.009728557     0.004761887   -0.05069851
## Precipitation.in. 0.03617412  0.101174144    -0.104794100   -0.10133502
##                    Humidity... Pressure.in. Visibility.mi. Wind_Speed.mph.
## Severity          0.086876542  0.065671149    -0.01784787    -0.062056779
```

```
## Distance.mi.          0.004473866 -0.008218439    -0.04147742     0.009728557
## Temperature.F.       -0.452662114  0.055390478     0.25676600     0.004761887
## Wind_Chill.F.        -0.435379799  0.050407389     0.26208308    -0.050698506
## Humidity...           1.000000000  0.233181450    -0.39892391    -0.137092830
## Pressure.in.          0.233181450  1.000000000    -0.26428984    -0.014390090
## Visibility.mi.       -0.398923914 -0.264289840     1.00000000     0.014696688
## Wind_Speed.mph.      -0.137092830 -0.014390090     0.01469669     1.000000000
## Precipitation.in.     0.244133880  0.007382003    -0.24473243     0.020686860
##                   Precipitation.in.
## Severity                0.036174121
## Distance.mi.            0.101174144
## Temperature.F.         -0.104794100
## Wind_Chill.F.          -0.101335015
## Humidity...             0.244133880
## Pressure.in.            0.007382003
## Visibility.mi.         -0.244732428
## Wind_Speed.mph.         0.020686860
## Precipitation.in.       1.000000000
```

```r
# Removinf the wind chills attribute #
# since "wind chills had a high correlation with temperature, it is removed
num<-num[-c(4)]

# Checking the new dimensions
nrow(num)
```

```
## [1] 500
```

```r
ncol(num)
```

```
## [1] 8
```

```r
# Scaling the new data set for better accuracies in clustering
num<-scale(num)

# Determine number of clusters
wss <- (nrow(num)-1)*sum(apply(num,2,var))
for (i in 2:15) wss[i] <- sum(kmeans(num,
                                centers=i)$withinss)
plot(wss)
#here we observe that after 8-10 clusters, the distance remains almost constant, so we fix this number

## Loading the cluster library ###
library(cluster)
library(factoextra)
```

```
## Loading required package: ggplot2
```

```
## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```
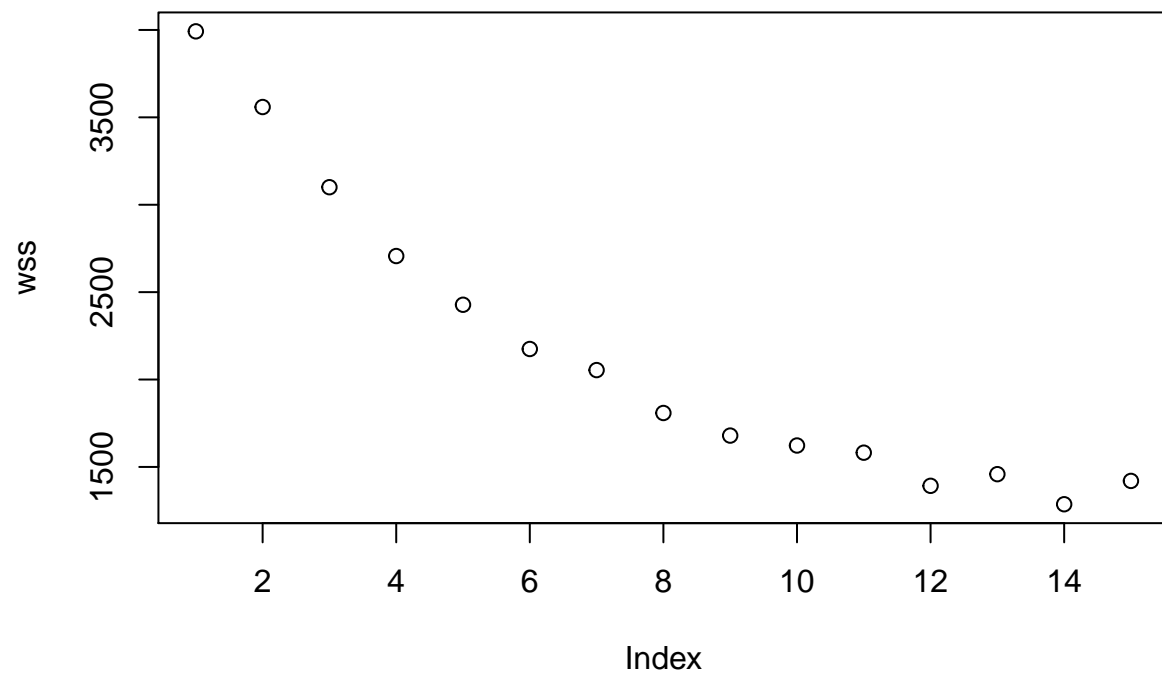
```
# Understanding different methods

# producing a distance matrix of the dataset
numdist<-dist(num,method = "euclidean")

#Sliced dendrograms for better visualizations

hc <- hclust(dist(num))
hcd <- as.dendrogram(hc)
plot(hcd, main="Main")
```

Main
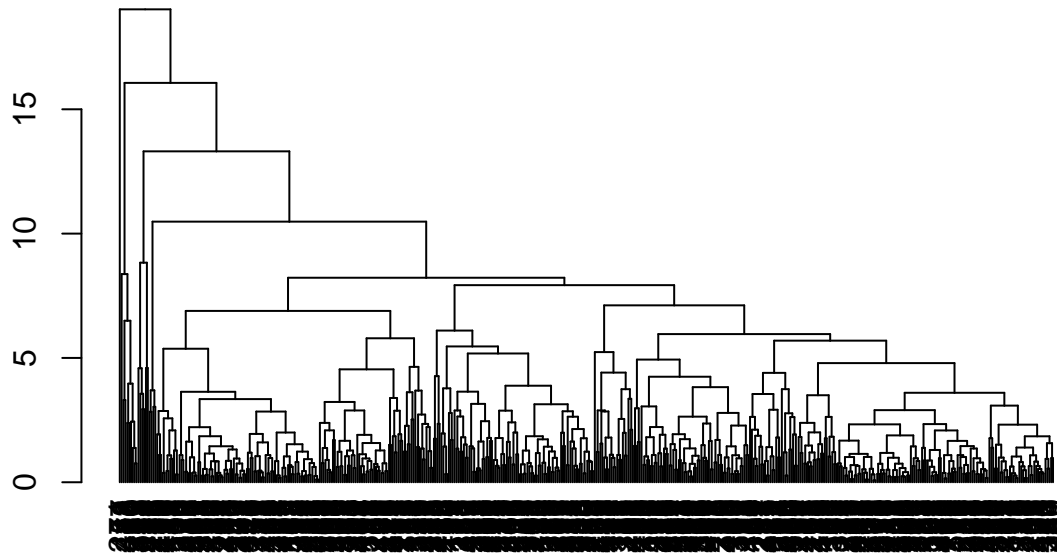

```
plot(cut(hcd, h=5)$upper,
     main="Upper tree of cut at h=5")
```

Upper tree of cut at h=5
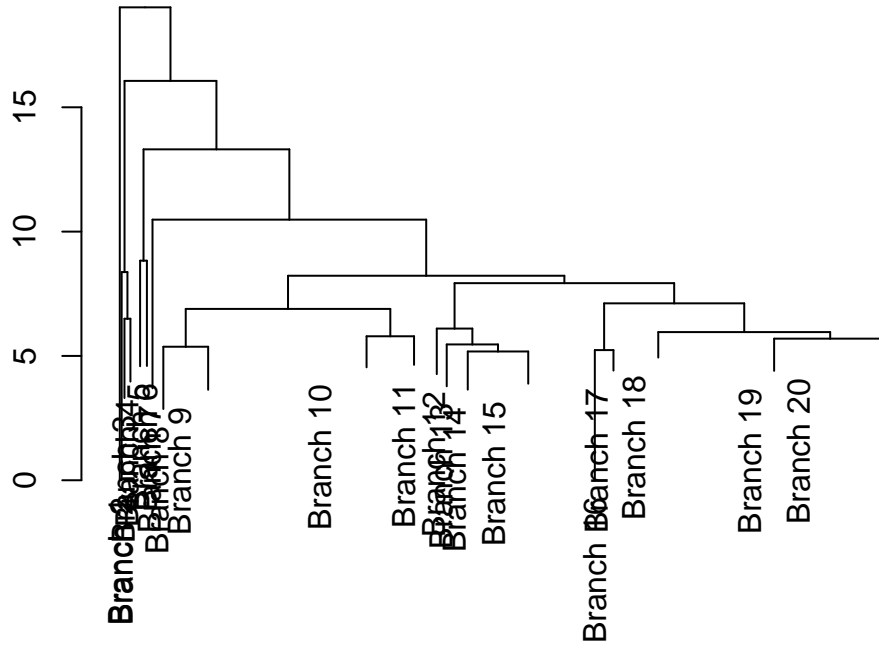

```
plot(cut(hcd, h=5)$lower[[2]],
     main="Second branch of lower tree with cut at h=5")
```

Second branch of lower tree with cut at h=5
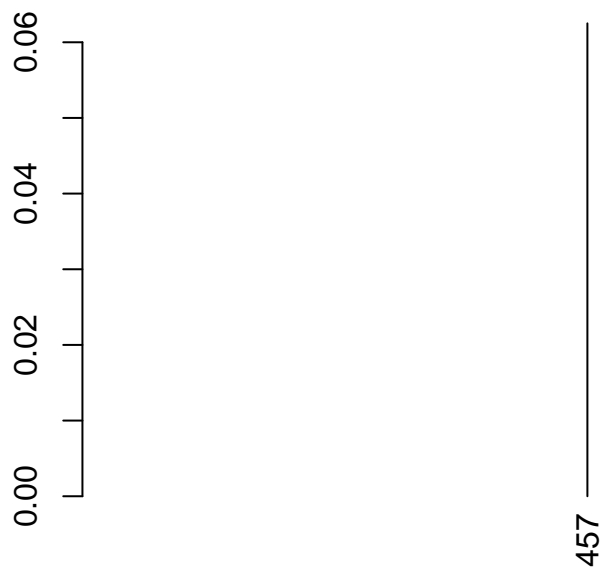

```r
#Single

numsingle<- hclust(numdist, method = "single")
single<-as.dendrogram(numsingle)
plot(single,main="Main")
```

Main
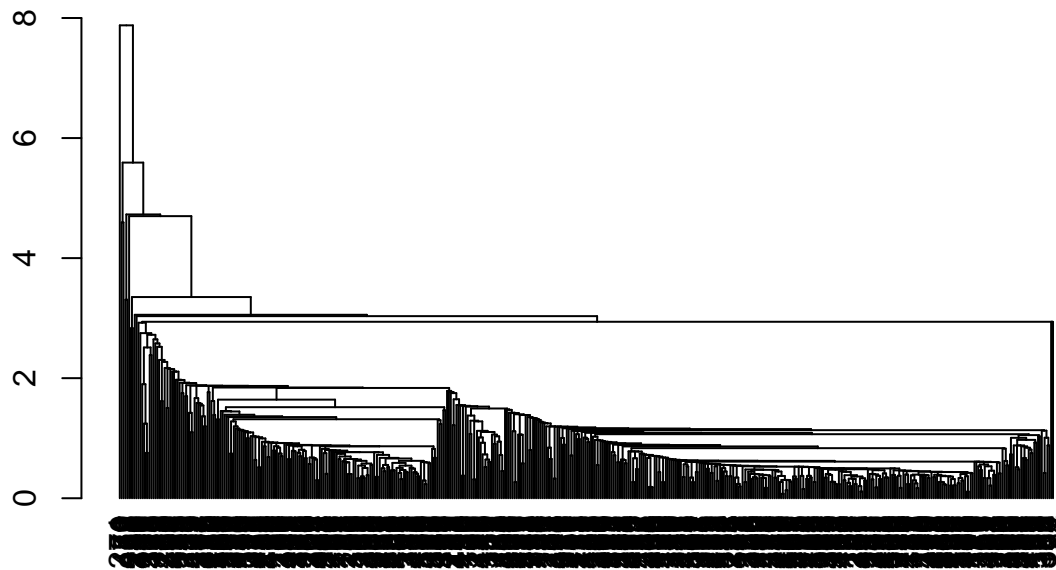

```r
plot(cut(single,h=1)$upper,xlab="Object",ylab="Distance",
     main="Dendrogram. Nearest neighbor linkage")
```

Dendrogram. Nearest neighbor linkage


```
plot(cut(single,h=1)$lower[[2]],xlab="Object",ylab="Distance",
     main="Dendrogram. Nearest neighbor linkage")
```

Dendrogram. Nearest neighbor linkage
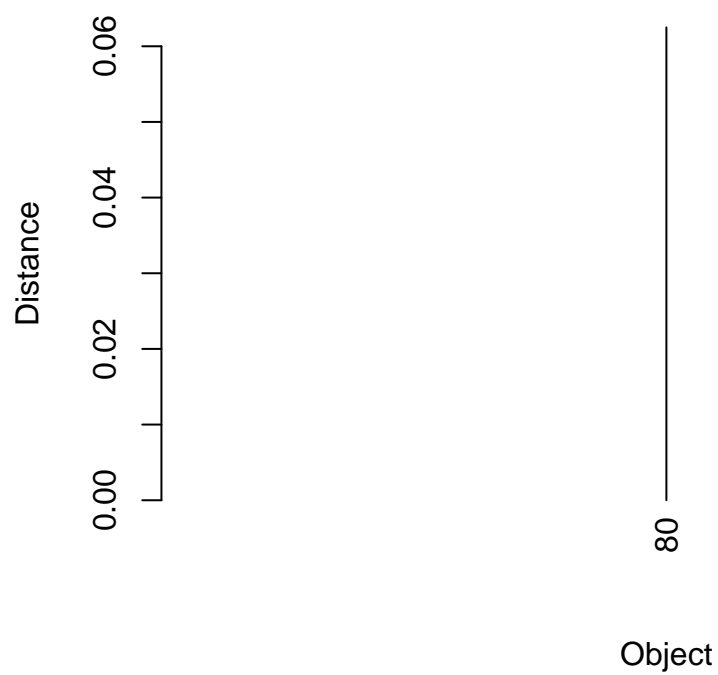
Object

```r
# Complete link
numcomplete<-hclust(numdist)
plot(numcomplete, hang=-1,xlab="Object",ylab="Distance",
     main="Dendrogram. Farthest neighbor linkage")
```

Dendrogram. Farthest neighbor linkage
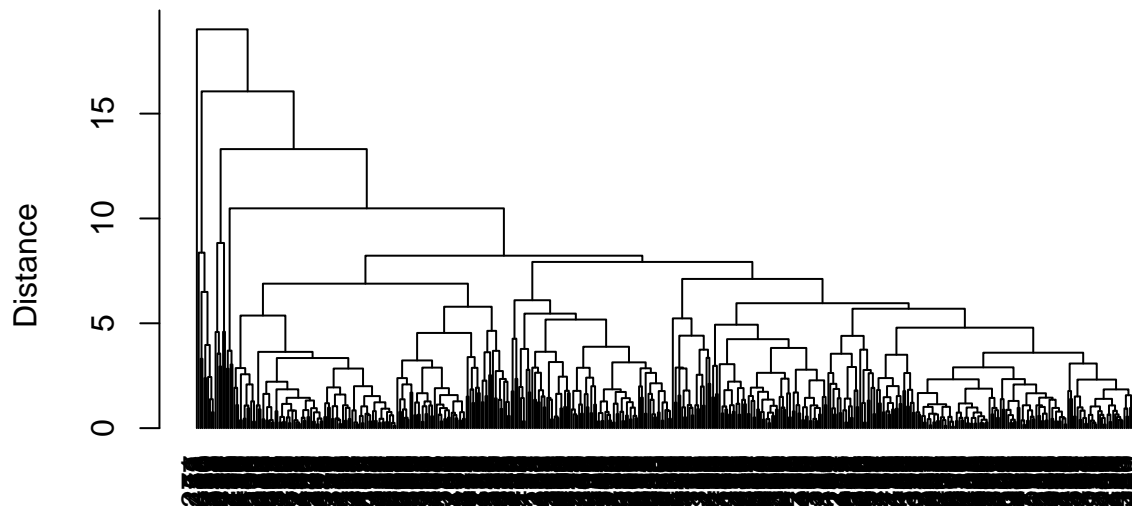
Object
hclust (*, "complete")

```r
# Average linkage
numaverage<-hclust(numdist)
plot(numaverage, hang=-1,xlab="Object",ylab="Distance",
     main="Dendrogram. Group average linkage")
```

Dendrogram. Group average linkage

Object
hclust (*, "complete")
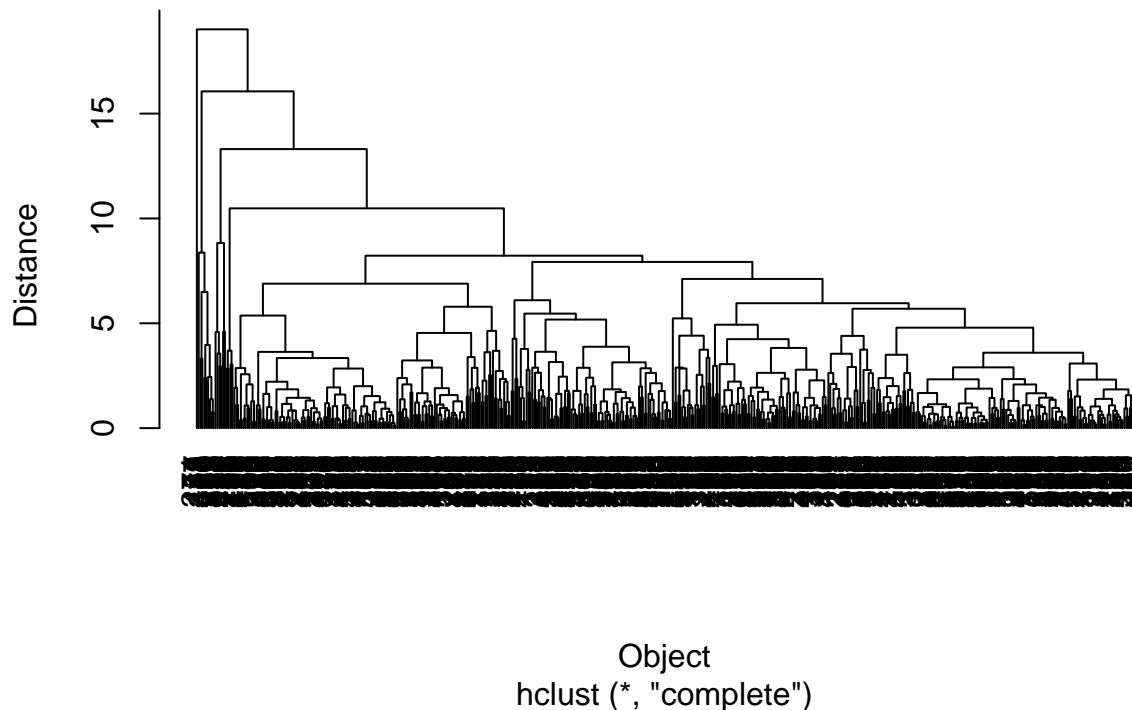
```
# Single link clustering
km.res<-kmeans(num,centers = 10,iter.max = 10,nstart = 3)
print(km.res)
```

```
## K-means clustering with 10 clusters of sizes 4, 10, 12, 66, 92, 16, 21, 118, 63, 98
##
## Cluster means:
##       Severity Distance.mi. Temperature.F. Humidity... Pressure.in.
## 1   0.3743416 -0.286109267    -0.23287818 -1.05967239  -3.80953332
## 2   0.1908408  0.826887066    -0.40688757  1.14095972   0.14273235
## 3   0.2214243  4.773803896     0.08429905 -0.03386252   0.02608219
## 4   0.1797195 -0.085547380    -1.30850887  1.02826788   0.23463854
## 5  -0.4434336 -0.167237674     0.90139423 -1.06906195   0.21588584
## 6  -0.3137863 -0.250997367    -1.28100876  0.48714091  -3.06267571
## 7  -0.3683996 -0.182746036     0.62953348 -1.57746213  -2.77625202
## 8  -0.5898150 -0.227487660    -0.11392558  0.54886337   0.37576459
## 9  -0.6014165 -0.126760851     0.10716318 -0.29267170   0.17486842
## 10  1.4603665 -0.007091685     0.21826522  0.02784033   0.30711587
##    Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1     7.35699377      0.15304465      -0.220774169
## 2    -1.26889254      0.11862939       6.138093483
## 3     0.06005446     -0.06922055      -0.071924271
## 4    -1.34121619      0.12019372       0.082338351
## 5     0.22570256     -0.22477502      -0.220774169
## 6    -0.19420836     -0.41695804       0.002500678
## 7     0.37677791     -0.05590513      -0.220774169
```

```
## 8      0.13776297    -0.62129863    -0.114813225
## 9      0.20867873     1.67441751    -0.152728501
## 10     0.16416466    -0.12807181    -0.173385222
##
## Clustering vector:
##   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##   9   5  10   8   9   4   4  10   8  10   5  10   5   5   6   2   8   8   9   8
##  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##  10   5   8   5   7  10   8   8   8   5  10   2   4  10   8   7  10  10   3   8
##  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##   5   4   4   7   8   4   8   5   5   8   9   8   8   4   9   1   5  10   6  10
##  61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##   6   4   9   9   4  10   4   7  10   5   9   8  10  10   9   4   8   8   7   3
##  81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##   5   9   4   8   9  10   4   2   4  10   5  10   8   4  10  10   5   4   6   8
## 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##   5   5   9   9   5   9  10   5  10   7   7   8   8  10   5   8   4   7   8   8
## 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##   9   8  10   8   8   9   7   8   5   8   9   8   8   9   4   5   3   9   8   5
## 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##   7   8   4  10   5   5   4   5   5   4  10   5   8   5   7   7   5  10   4   8
## 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##   4  10   8   9   4   4   7  10   8   4   9   5   5   8   9  10   9   9   4   8
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##   6   9   6   9   3  10   8   9   9  10   4   5   8  10  10   9  10  10   9  10
## 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##   4   4   8   4   4  10  10   5   8   5  10   3   7  10  10   5   5   4   9   9
## 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
##   7   3   5   3   9   4   8   8   4   4   5   8   8   8   8   8   9   1   8   8
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##   8   5   9  10   5   1   8   8   8  10  10   5   5   4   6  10   4   8   8   4
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##   8   8   9  10  10   8  10  10   9   8   1  10   2  10   8   4   4   8   4   9
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
##   9   8   9   5   8  10   5   6   5   7   5   5   9   5   5   5   4   8   8   8
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##  10  10   2   8  10   8   8   9   4   9   6  10   8  10  10   5   8   4   9   7
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##  10   4   8  10   5  10   4  10   9   6   5   5   8   4   5   7   5   9  10  10
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##   3   5  10   8   5   8  10   8   9   8   8   3   5   9  10  10   8   4  10  10
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
##   9   8   5   8   5   9   9   8   5   9   5   8   2   4  10  10  10   4  10   4
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##   8   5   8   5   3   4   5   5   8  10   5   5   8  10   5   8   8  10  10   8
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##  10   6   5  10   8   9   6  10   7  10  10   9   2   5  10   5   8   5   8  10
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##   9   8   9   5   8   7   9   8   8   4   8   4   5   5   7   6   8   3   9  10
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##  10   6   6   5   8   6  10   9   5   9   4   4   5   4  10   4   2   5   5  10
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##   8   5   4   4   8   2  10   8   4   5   8   3  10   9   8   8   4   8   4   2
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
```

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```
##     5   10    9    4    5    5    8    8    8    5    5   10   10    9    5    4    8    5   10    8
##
## Within cluster sum of squares by cluster:
##  [1]   57.42334 113.61006 145.09099 265.51365 143.53003   53.86346   71.31594
##  [8] 186.17083 197.33970 251.18168
##  (between_SS / total_SS =   62.8 %)
##
## Available components:
##
## [1] "cluster"        "centers"        "totss"          "withinss"       "tot.withinss"
## [6] "betweenss"      "size"           "iter"           "ifault"
```

```r
# Ward Hierarchical Clustering
fit <- hclust(numdist, method="ward")
```

```
## The "ward" method has been renamed to "ward.D"; note new "ward.D2"
```

```r
# display dendogram
plot(fit)
```


Cluster Dendrogram

numdist
hclust (*, "ward.D")
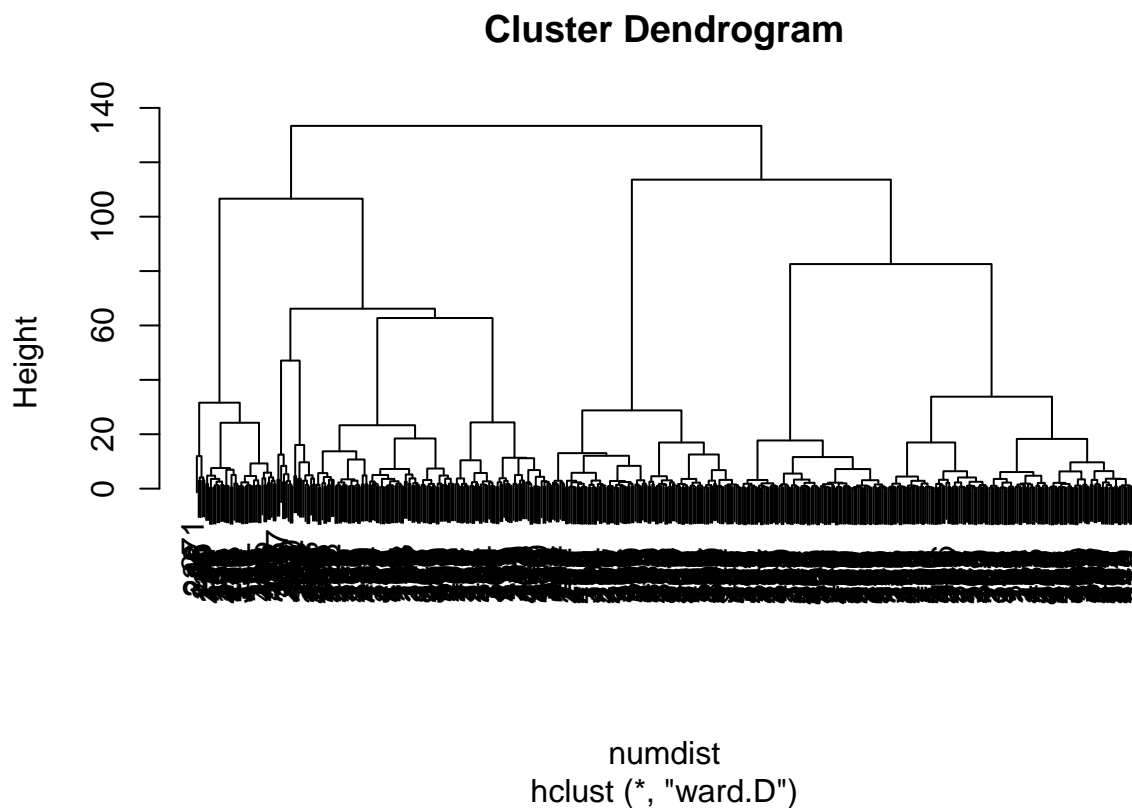
```r
# using the agnes function for all options in a single line code
?agnes
# Agglomerative Nesting (Hierarchical Clustering)
(agn.num <- agnes(num, metric="euclidean", stand=TRUE, method = "single"))
```

```
## Call:       agnes(x = num, metric = "euclidean", stand = TRUE, method = "single")
## Agglomerative coefficient:  0.9225946
## Order of objects:
##   [1] 1    189 64   308 421 82   85   263 367 177 171 2    148 173 353 335 462 11
##  [19] 459 382 434 458 22   388 296 403 449 49   81   387 102 291 154 30   172 470
##  [37] 57   105 145 29   116 122 348 132 393 169 270 468 350 419 372 35   40   248
##  [55] 53   120 193 77   351 93   100 445 208 418 242 217 491 245 325 210 444 498
##  [73] 252 304 500 112 431 228 300 234 240 364 306 400 488 422 428 478 395 72
##  [91] 84   489 119 239 487 152 363 495 153 160 298 368 104 283 483 220 384 23
## [109] 45   78   405 497 307 437 461 465 417 50   174 278 285 247 133 139 142 266
## [127] 28   357 313 396 227 333 233 97   216 284 24   235 475 101 115 369 392 481
## [145] 236 163 289 371 13   485 14   345 192 391 41   51   223 342 134 269 280 131
## [163] 237 113 203 258 389 47   397 20   146 70   157 5    108 317 370 294 365 433
## [181] 414 295 275 140 232 91   490 52   62   425 471 106 439 486 231 476 243 293
## [199] 354 474 249 125 282 187 17   406 310 366 344 63   429 361 332 196 412 138
## [217] 261 346 323 175 221 320 316 259 209 130 241 225 7    42   204 161 427 164
## [235] 494 281 6    165 18   362 33   327 159 378 65   218 452 191 469 229 334 358
## [253] 430 135 463 147 477 126 149 329 349 129 338 484 87   121 432 201 456 279
## [271] 178 4    230 128 27   381 383 448 3    26   197 404 398 312 37   190 176 411
## [289] 482 86   95   492 379 162 376 151 441 206 326 12   328 360 399 408 69   158
## [307] 109 31   410 48   60   198 253 195 265 359 287 8    274 455 355 493 21   123
## [325] 74   305 214 250 211 268 66   264 420 186 38   200 301 394 347 467 424 453
## [343] 447 34   58   96   267 343 377 401 302 319 90   356 168 277 286 499 297 315
## [361] 43   166 67   260 374 170 117 479 202 257 386 226 454 339 460 254 318 10
## [379] 144 390 73   92   76   276 309 188 251 219 340 114 256 324 194 207 321 15
## [397] 44   59   330 442 181 311 68   110 435 127 183 446 118 36   111 155 336 103
## [415] 167 156 426 46   124 450 54   75   136 337 215 272 89   79   409 213 55   182
## [433] 141 290 180 199 107 415 473 244 179 496 184 99   443 299 150 451 292 331
## [451] 9    39   212 385 222 185 314 19   262 61   205 416 288 407 352 436 402 380
## [469] 464 94   423 98   71   322 341 83   480 375 440 16   32   273 303 373 466 25
## [487] 143 56   238 246 137 224 438 255 80   472 457 88   413 271
## Height (summary):
##     Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
##  0.09727  0.57043  0.92079  1.30261  1.59595 15.08708
##
## Available components:
## [1] "order"     "height"   "ac"        "merge"      "diss"       "call"
## [7] "method"    "order.lab" "data"
```

```
#View(agn.num)

# Description of cluster merging
agn.num$merge
```

```
##        [,1] [,2]
##   [1,]  -78 -405
##   [2,] -403 -449
##   [3,] -169 -270
##   [4,] -461 -465
##   [5,]  -72  -84
##   [6,]  -53 -120
##   [7,]  -35  -40
##   [8,] -294 -365
##   [9,] -148 -173
```

```
## [10,] -296    2
## [11,] -102 -291
## [12,] -112 -431
## [13,] -217 -491
## [14,]    8 -433
## [15,] -306 -400
## [16,] -382 -434
## [17,]  -64 -308
## [18,] -239 -487
## [19,]  -81 -387
## [20,]   -2    9
## [21,]  -57 -105
## [22,] -174 -278
## [23,] -228 -300
## [24,] -227 -333
## [25,]    1 -497
## [26,] -335 -462
## [27,]    6 -193
## [28,]   15 -488
## [29,] -307 -437
## [30,] -106 -439
## [31,] -425 -471
## [32,]   11 -154
## [33,] -392 -481
## [34,] -201 -456
## [35,] -132 -393
## [36,]  -95 -492
## [37,] -113 -203
## [38,]   36 -379
## [39,]   29    4
## [40,]  -11 -459
## [41,]   25   39
## [42,] -240 -364
## [43,]   27  -77
## [44,]   42   28
## [45,]  -26 -197
## [46,]   12   23
## [47,] -122 -348
## [48,] -208 -418
## [49,]   40   16
## [50,]  -30 -172
## [51,]  -49   19
## [52,]   51   32
## [53,] -164 -494
## [54,]  -50   22
## [55,] -139 -142
## [56,] -210 -444
## [57,]  -22 -388
## [58,]   17 -421
## [59,] -214 -250
## [60,]   47   35
## [61,] -369   33
## [62,]   57   10
## [63,] -160 -298
```

```
##  [64,]  -245 -325
##  [65,]   -36 -111
##  [66,]  -363 -495
##  [67,]    46 -234
##  [68,]  -100 -445
##  [69,]  -133   55
##  [70,]    62   52
##  [71,]  -104 -283
##  [72,]  -347 -467
##  [73,]   -37 -190
##  [74,]  -216 -284
##  [75,]  -428 -478
##  [76,]  -156 -426
##  [77,]    56 -498
##  [78,]   -13 -485
##  [79,]    43 -351
##  [80,]  -152   66
##  [81,]    70   50
##  [82,]     3 -468
##  [83,]    67   44
##  [84,]   -12 -328
##  [85,]     7 -248
##  [86,]    48 -242
##  [87,]    83 -422
##  [88,]   -51 -223
##  [89,]     5 -489
##  [90,]    84 -360
##  [91,]   -93   68
##  [92,]  -350 -419
##  [93,]   -69 -158
##  [94,]    -1 -189
##  [95,]    60   82
##  [96,]    13   64
##  [97,]    86   96
##  [98,]    20 -353
##  [99,]    54 -285
## [100,]    87   75
## [101,]    49 -458
## [102,]    79   91
## [103,]  -235 -475
## [104,]  -119   18
## [105,]  -116   95
## [106,]    71 -483
## [107,]    41 -417
## [108,]    73 -176
## [109,]  -192 -391
## [110,]    99 -247
## [111,]  -269 -280
## [112,]   105   92
## [113,]    81 -470
## [114,]   -29  112
## [115,]   -82  -85
## [116,]   -45  107
## [117,]    45 -404
```

```
## [118,]   69 -266
## [119,]  113   21
## [120,]  108 -411
## [121,]  101  119
## [122,]  -60 -198
## [123,]  106 -220
## [124,]  110  118
## [125,]  -23  116
## [126,] -399 -408
## [127,] -263 -367
## [128,]   85  102
## [129,]  114 -372
## [130,]  129  128
## [131,]   77 -252
## [132,]  125  124
## [133,]   -8 -274
## [134,]  -28 -357
## [135,]  132  134
## [136,]  121 -145
## [137,] -163 -289
## [138,]   63 -368
## [139,]  122 -253
## [140,]   97  131
## [141,]  130  140
## [142,]   90  126
## [143,]  120 -482
## [144,]  141 -304
## [145,]  136  144
## [146,] -153  138
## [147,]  133 -455
## [148,] -355 -493
## [149,]  145 -500
## [150,]  149  100
## [151,]  150 -395
## [152,]  135 -313
## [153,] -151 -441
## [154,]  151   89
## [155,]  152 -396
## [156,]  154  104
## [157,] -381 -383
## [158,]  156   80
## [159,]  143  -86
## [160,]  158  146
## [161,]  -14 -345
## [162,]  155   24
## [163,]  -70 -157
## [164,]  -59 -330
## [165,]   98   26
## [166,]   58  115
## [167,]  160  123
## [168,]  166  127
## [169,]  117 -398
## [170,]  167 -384
## [171,]   88 -342
```

```
## [172,]   171 -134
## [173,]   170  162
## [174,]   153 -206
## [175,]   169 -312
## [176,] -229 -334
## [177,]    -3  175
## [178,] -101 -115
## [179,]    37 -258
## [180,]    78  161
## [181,]   -41  172
## [182,]   173 -233
## [183,]   182  -97
## [184,]   183   74
## [185,]   177  159
## [186,]   -52  -62
## [187,]    94  168
## [188,]   184  -24
## [189,]   187 -177
## [190,] -200 -301
## [191,]   188  103
## [192,]   191  178
## [193,]   176 -358
## [194,]   192   61
## [195,]   165  194
## [196,]   -31 -410
## [197,]   189 -171
## [198,] -293 -354
## [199,]   137 -371
## [200,] -195 -265
## [201,]   195 -236
## [202,]   201  199
## [203,]   180  109
## [204,]   147  148
## [205,]   202  203
## [206,]   197  205
## [207,]   142   93
## [208,]    38 -162
## [209,]   206  181
## [210,]   208 -376
## [211,]   209  111
## [212,]   185  210
## [213,]   211 -131
## [214,]   213 -237
## [215,]   214  179
## [216,]   215 -389
## [217,]   139  200
## [218,] -310 -366
## [219,]   198 -474
## [220,]   -48  217
## [221,] -110 -435
## [222,]   212  174
## [223,]   207 -109
## [224,] -181 -311
## [225,]   216  -47
```

```
## [226,]  -38  190
## [227,] -264 -420
## [228,]  225 -397
## [229,] -218 -452
## [230,]  228  -20
## [231,]  230 -146
## [232,]  231  163
## [233,]  232   -5
## [234,]  233 -108
## [235,] -261 -346
## [236,]  234 -317
## [237,] -129 -338
## [238,]  223  196
## [239,]  -90 -356
## [240,]  222 -326
## [241,]   14 -414
## [242,]  236 -370
## [243,]  220 -359
## [244,]  226 -394
## [245,] -424 -453
## [246,]  242  241
## [247,]  -21 -123
## [248,]  -73  -92
## [249,]  239 -168
## [250,]  238  243
## [251,] -243  219
## [252,]  240  250
## [253,]  -42 -204
## [254,] -212 -385
## [255,]  186   31
## [256,]  -91 -490
## [257,]  246 -295
## [258,]  164 -442
## [259,]  -67 -260
## [260,]  257 -275
## [261,]  252 -287
## [262,]  260 -140
## [263,]  262 -232
## [264,]  261  204
## [265,] -117 -479
## [266,]  263  256
## [267,]  264  247
## [268,]  267  -74
## [269,] -257 -386
## [270,] -196 -412
## [271,]  244   72
## [272,]  -65  229
## [273,]  268 -305
## [274,]  273   59
## [275,] -125 -282
## [276,] -292 -331
## [277,]  266  255
## [278,]  -66  227
## [279,]  277   30
```

```
## [280,]  279 -486
## [281,]  280 -231
## [282,]  274 -211
## [283,]  281 -476
## [284,]  258  224
## [285,]  282 -268
## [286,] -226 -454
## [287,]  249 -277
## [288,]  285  278
## [289,]  283  251
## [290,]  275 -187
## [291,] -273 -303
## [292,]  288 -186
## [293,]  292  271
## [294,]  289 -249
## [295,] -256 -324
## [296,]  -58  -96
## [297,] -221 -320
## [298,] -127 -183
## [299,]  293  245
## [300,]  294  290
## [301,]   -6 -165
## [302,]  253 -161
## [303,]  299 -447
## [304,]  303  -34
## [305,]  -43 -166
## [306,]  235 -323
## [307,]  305  259
## [308,]  300  -17
## [309,]  308 -406
## [310,]  272 -191
## [311,] -343 -377
## [312,]  311 -401
## [313,] -267  312
## [314,]  304  296
## [315,]  314  313
## [316,]  307 -374
## [317,]  309  218
## [318,]  315 -302
## [319,] -202  269
## [320,]  318 -319
## [321,]  317 -344
## [322,]  316 -170
## [323,]  310 -469
## [324,]  320  287
## [325,]  -68  221
## [326,]  -39  254
## [327,] -339 -460
## [328,]  325  298
## [329,] -159 -378
## [330,]  323  193
## [331,] -103 -167
## [332,]  321  -63
## [333,]  284  328
```

```
## [334,]   265   319
## [335,]   332  -429
## [336,]   -44   333
## [337,]  -286  -499
## [338,]   324   337
## [339,]   -18  -362
## [340,]    34  -279
## [341,]   322   334
## [342,]   338  -297
## [343,]   335  -361
## [344,]  -130  -241
## [345,]   343  -332
## [346,]   342  -315
## [347,]   346   341
## [348,]   345   270
## [349,]   -33  -327
## [350,]   347   286
## [351,]  -254  -318
## [352,]   297  -316
## [353,]   349   329
## [354,]   348  -138
## [355,]   350   327
## [356,]   354   306
## [357,]   336  -446
## [358,]   355   351
## [359,]   339   353
## [360,]   359   330
## [361,]   358   -10
## [362,]  -135  -463
## [363,]    -4  -230
## [364,]   361  -144
## [365,]   -27   157
## [366,]   356  -175
## [367,]   360  -430
## [368,]   367   362
## [369,]   368  -147
## [370,]    -7   302
## [371,]   366   352
## [372,]   371  -259
## [373,]   369  -477
## [374,]    65  -155
## [375,]   301   373
## [376,]   326  -222
## [377,]   364  -390
## [378,]   370  -427
## [379,]   372  -209
## [380,]   -15   357
## [381,]   379   344
## [382,]   381  -225
## [383,]   382   378
## [384,]   383    53
## [385,]   380  -118
## [386,]   374  -336
## [387,]   384  -281
```

```
## [388,]   387   375
## [389,]   -79  -409
## [390,]   388  -126
## [391,]  -329  -349
## [392,]   385   386
## [393,]   392   331
## [394,]   390  -149
## [395,]   394   391
## [396,]   395   237
## [397,]   363  -128
## [398,]   397   365
## [399,]   389  -213
## [400,]   -76  -276
## [401,]   377   248
## [402,]   401   400
## [403,]  -114   295
## [404,]   396  -484
## [405,]   404   -87
## [406,]   -99  -443
## [407,]   398  -448
## [408,]   402  -309
## [409,]   405  -121
## [410,]   -32   291
## [411,]   408  -188
## [412,]   411  -251
## [413,]  -415  -473
## [414,]   409  -432
## [415,]   414   340
## [416,]   415  -178
## [417,]   412  -219
## [418,]   417  -340
## [419,]   418   403
## [420,]  -215  -272
## [421,]  -136  -337
## [422,]  -124  -450
## [423,]   416   407
## [424,]   419  -194
## [425,]   424  -207
## [426,]  -107   413
## [427,]   425  -321
## [428,]   393    76
## [429,]   -55  -182
## [430,]   423   427
## [431,]   430   428
## [432,]   431   -46
## [433,]   432   422
## [434,]  -380  -464
## [435,]   433   -54
## [436,]   435   -75
## [437,]   436   421
## [438,]   437   420
## [439,]   438   -89
## [440,]   439   399
## [441,]   440   429
```

```
## [442,] -141 -290
## [443,]  441  442
## [444,]  443 -180
## [445,]  444 -199
## [446,]  426 -244
## [447,]  445  446
## [448,]  447 -179
## [449,]  376 -185
## [450,] -288 -407
## [451,]   -9  449
## [452,] -150 -451
## [453,]  448 -496
## [454,]  453 -184
## [455,]  454  406
## [456,]  455 -299
## [457,]  456  452
## [458,]  457  276
## [459,]  458  451
## [460,]  -19 -262
## [461,] -375 -440
## [462,]  459 -314
## [463,]  462  460
## [464,]  -83 -480
## [465,]  463  -61
## [466,]  465 -205
## [467,]  466 -416
## [468,]  467  450
## [469,]  468 -352
## [470,]  469 -436
## [471,]  470 -402
## [472,]  471  434
## [473,]  472  -94
## [474,]  473 -423
## [475,]  474  -98
## [476,] -238 -246
## [477,] -373 -466
## [478,]  -16  410
## [479,]  475  -71
## [480,]  479 -322
## [481,]  480 -341
## [482,]  -56  476
## [483,]  481  464
## [484,]  483  461
## [485,]  478  477
## [486,] -137 -224
## [487,]  -88 -413
## [488,]  484  485
## [489,]  488  -25
## [490,]  486 -438
## [491,]  489 -143
## [492,]  491  482
## [493,]  492  490
## [494,]  493 -255
## [495,]  -80 -472
```

```
## [496,]  494   495
## [497,]  496  -457
## [498,]  497   487
## [499,]  498  -271
```

```
#Dendogram
plot(as.dendrogram(agn.num), xlab= "US Accidents Dendrogram",xlim=c(8,0),
     horiz = TRUE,main="Dendrogram for us accident records")
```

Dendrogram for us accident records
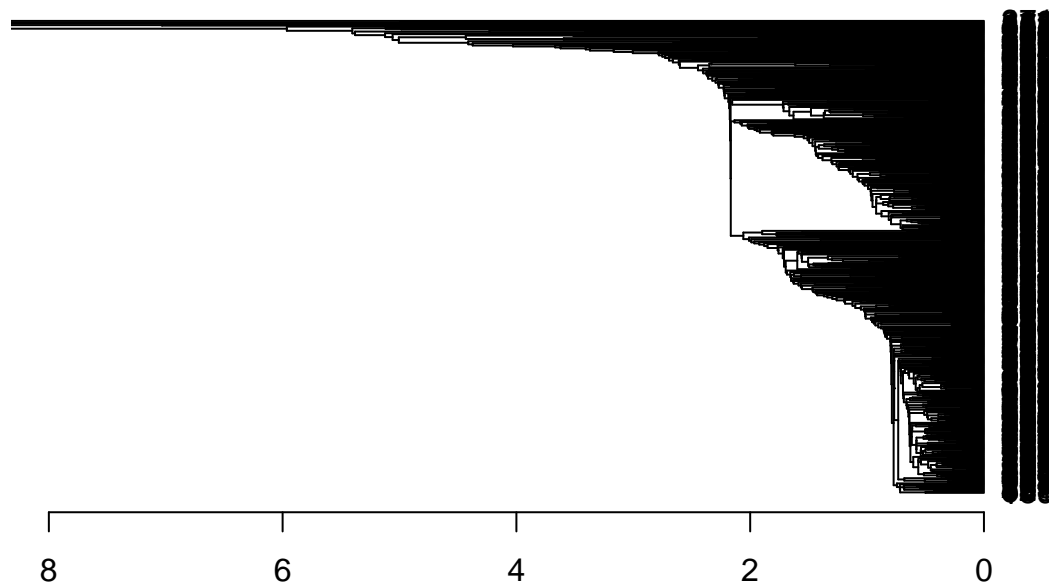
US Accidents Dendrogram

```
plot(as.dendrogram(agn.num), xlab= "US Accidents Dendrogram",xlim=c(2,0),
     horiz = TRUE,main="Dendrogram for us accident records")
```

Dendrogram for us accident records
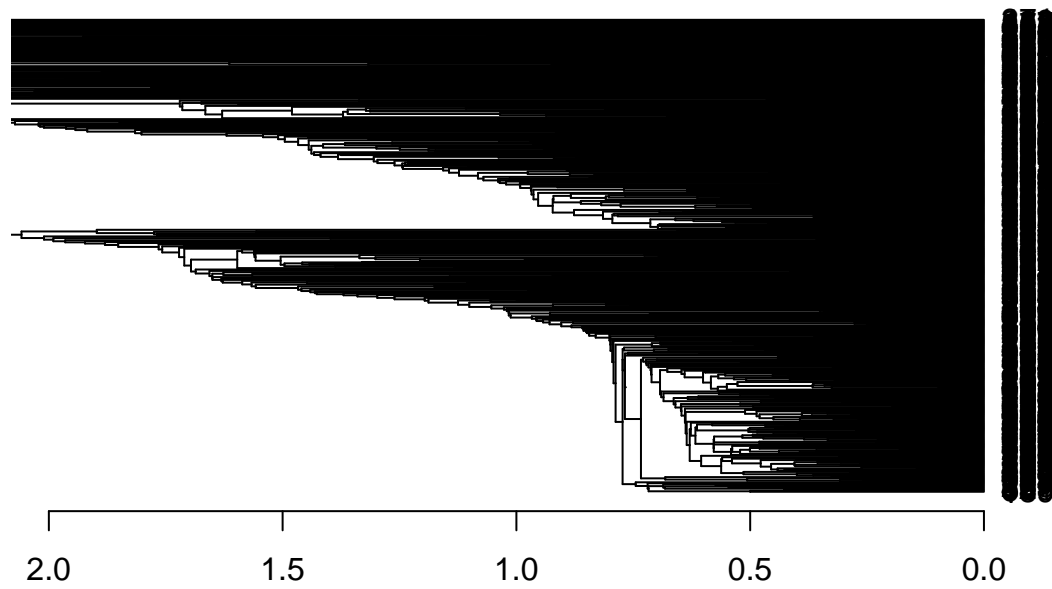
US Accidents Dendrogram

```
plot(as.dendrogram(agn.num), xlab= "US Accidents Dendrogram",xlim=c(1,0),
     horiz = TRUE,main="Dendrogram for us accident records")
```

Dendrogram for us accident records
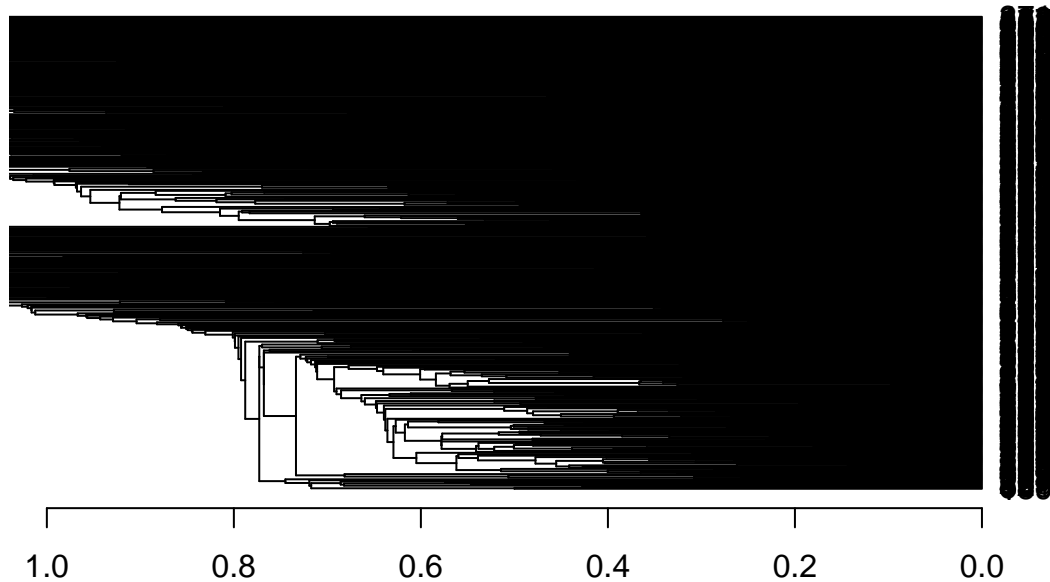
US Accidents Dendrogram

```
#Interactive Plots,
#plot(agn.num,ask=TRUE)
#plot(agn.num, which.plots=2)



#K-Means Clustering



# K-means, k=2, 3, 4, 5, 6
# Centers (k's) are numbers thus, 10 random sets are chosen



# Computing the percentage of variation accounted for. Two clusters
matstd.num<- scale(num[,1:8])
(kmeans2.num <- kmeans(matstd.num,2,nstart = 10))
```

```
## K-means clustering with 2 clusters of sizes 252, 248
##
## Cluster means:
##     Severity Distance.mi. Temperature.F. Humidity... Pressure.in.
## 1  0.1486065   0.02752796    -0.6182097   0.7626184   0.09499899
## 2 -0.1510034  -0.02797196     0.6281808  -0.7749187  -0.09653123
##   Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1    -0.3542998     -0.2346050          0.2130170
## 2     0.3600143      0.2383889         -0.2164527
##
```

```
## Clustering vector:
##   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##   2   2   2   1   2   1   1   2   1   2   2   1   2   2   1   1   1   1   2   1
##  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##   1   2   1   2   2   2   1   1   1   2   2   1   1   1   1   2   1   2   1   1
##  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##   2   1   1   2   1   1   1   2   2   1   2   1   2   1   2   2   2   1   1   2
##  61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##   1   1   1   2   1   1   1   2   1   2   1   1   1   1   1   1   2   1   2   2
##  81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##   2   2   1   1   2   2   1   1   1   1   2   1   2   1   1   1   2   1   1   2
## 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##   2   2   2   2   2   2   1   2   1   2   2   2   2   2   2   1   1   2   1   2
## 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##   1   1   2   2   2   2   2   1   2   1   2   1   1   2   1   2   1   1   1   2
## 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##   2   1   1   2   2   2   1   2   2   1   2   2   1   2   2   2   2   1   1   1
## 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##   1   1   2   2   1   1   2   1   1   1   2   2   2   1   2   2   1   1   1   1
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##   1   2   2   1   1   2   1   2   2   2   1   2   2   1   2   2   2   2   2   1
## 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##   1   1   2   1   1   1   2   2   1   2   1   2   2   2   1   2   2   1   2   2
## 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
##   2   2   2   1   2   1   1   1   1   1   2   1   1   1   2   1   2   2   2   2
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##   2   2   2   2   2   2   1   1   1   2   1   2   2   1   1   2   1   2   2   1
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##   1   2   2   1   2   1   1   2   2   1   2   1   1   2   1   1   1   1   1   2
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
##   1   1   2   2   1   1   2   1   2   2   2   2   2   2   2   2   1   1   1   1
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##   2   1   1   1   2   1   1   2   1   2   1   2   1   1   2   2   1   1   2   2
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##   1   1   1   2   2   1   1   1   2   1   2   2   1   1   2   2   2   2   1   2
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##   1   2   1   1   2   1   2   1   2   1   2   2   2   2   2   1   1   1   1   1
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
##   1   1   2   1   2   2   2   1   2   2   2   2   1   1   1   1   1   1   1   1
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##   1   2   1   2   2   1   2   2   1   1   2   2   1   2   2   1   1   2   2   1
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##   1   1   2   2   1   2   1   2   2   2   2   2   1   2   2   2   1   2   1   1
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##   2   1   2   2   1   2   1   2   1   1   2   1   2   2   2   1   1   1   2   1
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##   1   1   1   2   2   1   2   1   2   2   1   1   2   1   2   1   1   2   2   1
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##   1   2   1   1   1   1   2   1   1   2   1   2   1   2   2   1   1   2   1   1
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##   2   1   2   1   2   2   2   1   1   2   2   1   2   2   2   1   1   2   1   1
##
## Within cluster sum of squares by cluster:
## [1] 1824.705 1546.653
```

```
##   (between_SS / total_SS =  15.5 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```
perc.var.2 <- round(100*(1 - kmeans2.num$betweenss/kmeans2.num$totss),1)
names(perc.var.2) <- "Perc. 2 clus"
perc.var.2
```

```
## Perc. 2 clus
##         84.5
```

```
# Computing the percentage of variation accounted for. Three clusters
(kmeans3.num <- kmeans(matstd.num,3,nstart = 10))
```

```
## K-means clustering with 3 clusters of sizes 10, 241, 249
##
## Cluster means:
##      Severity Distance.mi. Temperature.F. Humidity... Pressure.in.
## 1  0.1908408  0.826887066     -0.4068876   1.1409597    0.1427323
## 2 -0.1776836 -0.030426898      0.6445745  -0.7904393   -0.1152943
## 3  0.1643106 -0.003758989     -0.6075244   0.7192220    0.1058578
##   Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1     -1.2688925       0.1186294        6.13809348
## 2      0.3609564       0.2647871       -0.21484488
## 3     -0.2983999      -0.2610441       -0.03856755
##
## Clustering vector:
##    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##    2   2   2   3   2   3   3   2   3   3   2   3   2   2   3   1   3   3   2   3
##   21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##    3   2   3   2   2   2   3   3   3   2   2   1   3   3   3   2   3   2   3   3
##   41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##    2   3   3   2   3   3   3   2   2   3   2   3   2   3   2   2   2   3   3   2
##   61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##    3   3   3   2   3   3   3   2   3   2   3   3   3   3   3   3   2   3   2   2
##   81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##    2   2   3   3   2   2   3   1   3   3   2   3   2   3   3   3   2   3   3   2
##  101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##    2   2   2   2   2   2   3   2   3   2   2   2   2   2   2   3   3   2   3   3
##  121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##    3   3   2   2   2   2   2   3   2   3   2   3   3   2   3   2   3   3   3   2
##  141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##    2   3   3   2   2   2   3   2   2   3   2   2   3   2   2   2   2   3   3   3
##  161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##    3   3   2   2   3   3   2   3   3   3   2   2   2   3   2   2   3   2   3   3
##  181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##    3   2   2   3   3   2   3   2   2   3   3   2   3   3   2   2   2   2   2   3
##  201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##    3   3   2   3   3   3   2   2   3   2   3   2   2   2   3   2   2   3   2   2
##  221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
```

```
##   2   2   2   3   2   3   3   3   3   3   2   3   3   3   2   3   2   2   2   2
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##   2   2   2   2   2   2   3   3   3   2   3   2   2   3   3   2   3   2   2   3
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##   3   2   2   3   2   3   3   2   2   3   2   3   1   2   3   3   3   3   3   2
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
##   3   3   2   2   3   3   2   3   2   2   2   2   2   2   2   2   3   3   3   3
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##   3   3   1   3   2   3   3   2   3   2   3   2   3   3   2   2   3   3   2   2
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##   3   3   3   2   2   3   3   3   2   3   2   2   3   3   2   2   2   2   3   2
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##   3   2   3   3   2   3   2   3   2   3   2   2   2   2   2   3   3   3   3   3
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
##   3   3   2   3   2   2   2   3   2   2   2   2   1   3   3   3   3   3   3   3
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##   3   2   3   2   2   3   2   2   3   3   2   2   3   2   2   3   3   2   2   3
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##   3   3   2   2   3   2   3   2   2   2   2   2   1   2   3   2   3   2   3   3
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##   2   3   2   2   3   2   3   3   3   3   2   3   2   2   2   3   3   3   2   3
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##   3   3   3   2   2   3   2   3   2   2   3   3   2   3   2   3   1   2   2   3
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##   3   2   3   3   3   1   2   3   3   2   3   2   3   2   2   3   3   2   3   1
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##   2   3   2   3   2   2   3   3   3   2   2   3   2   2   2   3   3   2   3   3
##
## Within cluster sum of squares by cluster:
## [1]  113.6101 1519.3207 1353.0941
##  (between_SS / total_SS =  25.2 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"      "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
perc.var.3 <- round(100*(1 - kmeans3.num$betweenss/kmeans3.num$totss),1)

names(perc.var.3) <- "Perc. 3 clus"
perc.var.3
```

```
## Perc. 3 clus
##         74.8
```

```r
# Computing the percentage of variation accounted for. Four clusters
(kmeans4.num<- kmeans(matstd.num,4,nstart = 10))
```

```
## K-means clustering with 4 clusters of sizes 41, 10, 226, 223
##
## Cluster means:
##     Severity Distance.mi. Temperature.F. Humidity... Pressure.in.
## 1 -0.2746246  0.004734917    -0.09888672  -0.8244867   -2.9857488
```

```
## 2   0.1908408  0.826887066    -0.40688757    1.1409597     0.1427323
## 3   0.2119515  0.023318575    -0.61459811    0.7418733     0.2796961
## 4  -0.1728692 -0.061582961     0.65929329   -0.6514306     0.2590899
##    Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1       0.8790505     -0.07988788       -0.15106885
## 2      -1.2688925      0.11862939        6.13809348
## 3      -0.3308795     -0.26397385       -0.03267005
## 4       0.2306127      0.27689327       -0.21436628
##
## Clustering vector:
##    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20
##    4    4    4    3    4    3    3    4    3    3    4    3    4    4    1    2    3    3    4    3
##   21   22   23   24   25   26   27   28   29   30   31   32   33   34   35   36   37   38   39   40
##    3    4    3    4    1    4    3    3    3    4    4    2    3    3    4    1    3    4    3    4
##   41   42   43   44   45   46   47   48   49   50   51   52   53   54   55   56   57   58   59   60
##    4    3    3    1    3    3    3    4    4    3    4    3    4    3    4    1    4    3    1    4
##   61   62   63   64   65   66   67   68   69   70   71   72   73   74   75   76   77   78   79   80
##    1    3    3    4    3    3    3    1    3    4    3    3    3    3    3    3    4    3    1    4
##   81   82   83   84   85   86   87   88   89   90   91   92   93   94   95   96   97   98   99  100
##    4    4    3    3    4    4    3    2    3    3    4    3    4    3    3    3    4    3    1    4
##  101  102  103  104  105  106  107  108  109  110  111  112  113  114  115  116  117  118  119  120
##    4    4    1    4    4    4    3    4    3    1    1    4    4    4    4    3    3    1    3    4
##  121  122  123  124  125  126  127  128  129  130  131  132  133  134  135  136  137  138  139  140
##    3    3    4    4    4    4    1    3    4    3    4    3    3    4    3    4    3    3    3    4
##  141  142  143  144  145  146  147  148  149  150  151  152  153  154  155  156  157  158  159  160
##    1    3    3    4    4    4    3    4    4    3    4    4    3    4    1    1    4    3    3    3
##  161  162  163  164  165  166  167  168  169  170  171  172  173  174  175  176  177  178  179  180
##    3    3    4    4    3    3    1    3    3    3    4    4    4    3    4    4    3    4    3    3
##  181  182  183  184  185  186  187  188  189  190  191  192  193  194  195  196  197  198  199  200
##    1    4    1    3    3    4    3    4    4    4    3    4    4    3    4    4    4    4    4    3
##  201  202  203  204  205  206  207  208  209  210  211  212  213  214  215  216  217  218  219  220
##    3    3    4    3    3    3    4    4    3    4    3    4    1    4    3    4    4    3    4    4
##  221  222  223  224  225  226  227  228  229  230  231  232  233  234  235  236  237  238  239  240
##    1    4    4    3    4    3    3    3    3    3    4    3    3    3    4    3    4    1    4    4
##  241  242  243  244  245  246  247  248  249  250  251  252  253  254  255  256  257  258  259  260
##    4    4    4    4    4    1    3    4    3    4    3    4    4    3    1    4    3    4    4    3
##  261  262  263  264  265  266  267  268  269  270  271  272  273  274  275  276  277  278  279  280
##    3    4    4    3    4    3    3    4    4    3    1    3    2    4    4    3    3    3    3    4
##  281  282  283  284  285  286  287  288  289  290  291  292  293  294  295  296  297  298  299  300
##    3    3    4    4    3    3    4    3    4    1    4    4    4    4    4    4    3    3    3    3
##  301  302  303  304  305  306  307  308  309  310  311  312  313  314  315  316  317  318  319  320
##    3    3    2    3    4    3    3    4    3    4    1    4    3    3    4    4    3    3    4    1
##  321  322  323  324  325  326  327  328  329  330  331  332  333  334  335  336  337  338  339  340
##    3    3    3    4    4    3    3    3    4    1    4    4    3    3    4    1    4    4    3    4
##  341  342  343  344  345  346  347  348  349  350  351  352  353  354  355  356  357  358  359  360
##    3    4    3    3    4    3    4    3    4    3    4    4    4    4    4    3    3    3    3    3
##  361  362  363  364  365  366  367  368  369  370  371  372  373  374  375  376  377  378  379  380
##    3    3    4    3    4    4    4    3    4    4    4    4    2    3    3    3    3    3    3    3
##  381  382  383  384  385  386  387  388  389  390  391  392  393  394  395  396  397  398  399  400
##    3    4    3    4    4    3    4    4    3    3    4    4    3    4    4    3    3    4    4    3
##  401  402  403  404  405  406  407  408  409  410  411  412  413  414  415  416  417  418  419  420
##    3    1    4    4    3    4    1    4    1    4    4    4    2    4    3    4    3    4    4    3
##  421  422  423  424  425  426  427  428  429  430  431  432  433  434  435  436  437  438  439  440
##    4    3    4    4    3    1    3    4    3    3    4    3    4    4    1    1    3    3    4    3
```

```
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##   3   3   1   4   4   1   4   3   4   4   3   3   4   3   4   3   2   4   4   3
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##   3   4   3   3   3   2   4   3   3   4   3   1   3   4   4   3   3   4   3   2
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##   4   3   4   3   4   4   4   3   3   4   4   3   4   4   4   3   3   4   3   3
##
## Within cluster sum of squares by cluster:
## [1]  528.9751  113.6101 1118.6016  854.2970
##  (between_SS / total_SS =  34.5 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
perc.var.4 <- round(100*(1 - kmeans4.num$betweenss/kmeans4.num$totss),1)
names(perc.var.4) <- "Perc. 4 clus"
perc.var.4
```

```
## Perc. 4 clus
##         65.5
```

```r
# Computing the percentage of variation accounted for. Five clusters
(kmeans5.num <- kmeans(matstd.num,5,nstart = 10))
```

```
## K-means clustering with 5 clusters of sizes 37, 158, 16, 169, 120
##
## Cluster means:
##      Severity Distance.mi. Temperature.F. Humidity... Pressure.in.
## 1 -0.24559346  -0.21842156     -0.2094344  -0.7652081  -3.09931925
## 2 -0.57800420  -0.16871146     -0.5525952   0.7239109   0.25129884
## 3  0.03027763   2.91283925     -0.3041773   0.7462929  -0.04163422
## 4 -0.43458194  -0.08902735      0.7309719  -0.8053124   0.22195759
## 5  1.44476274   0.02648502     -0.1967358   0.3174324   0.31770759
##   Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1      0.9466474     -0.03995983       -0.14353314
## 2     -0.2441005     -0.32441259       -0.05798137
## 3     -0.9723333      0.06162912        3.97679296
## 4      0.2277958      0.37654018       -0.21231879
## 5     -0.1616520     -0.09904711       -0.11062524
##
## Clustering vector:
##    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##    4   4   5   2   4   2   2   5   2   5   4   5   4   4   1   3   2   2   4   2
##   21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##    5   4   2   4   1   5   2   2   2   4   5   3   2   5   2   1   5   5   2   2
##   41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##    4   2   5   1   2   5   2   4   4   2   4   2   2   2   4   1   4   5   1   5
##   61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##    1   2   2   4   2   5   5   1   5   4   2   2   5   5   2   5   4   2   1   3
##   81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##    4   4   5   2   4   5   2   3   2   5   4   5   4   2   5   5   4   5   1   4
```

```
## 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##   4   4   1   4   4   4   5   4   5   1   1   2   4   5   4   2   5   1   2   2
## 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##   2   2   5   4   4   4   1   2   4   2   4   2   2   4   2   4   3   2   2   4
## 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##   1   2   3   5   4   4   2   4   4   5   5   4   2   4   1   1   4   5   2   2
## 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##   2   5   4   4   2   5   1   5   2   5   4   4   4   2   4   5   2   4   2   2
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##   1   4   1   2   5   4   2   4   4   5   2   4   2   5   5   4   5   4   4   5
## 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##   2   5   4   2   2   5   4   4   2   4   5   4   1   5   5   4   4   2   5   4
## 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
##   4   4   4   3   4   5   2   2   2   2   4   2   2   2   4   2   4   1   2   2
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##   4   4   4   5   4   1   2   2   2   5   5   4   4   5   1   4   5   2   4   5
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##   2   2   4   5   5   2   5   4   4   2   1   5   3   4   2   5   5   2   2   4
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
##   2   2   4   4   2   5   4   2   4   1   4   4   4   4   4   4   5   2   2   2
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##   5   5   3   2   4   2   2   4   5   4   1   5   2   5   5   4   2   5   4   4
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##   5   2   2   5   4   5   2   5   4   2   4   4   2   2   4   1   4   4   5   5
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##   5   4   5   2   4   2   5   2   4   2   4   4   4   4   5   5   2   2   5   5
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
##   2   2   4   2   4   4   4   2   4   4   4   2   3   5   5   5   5   2   5   5
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##   2   4   2   4   4   5   4   4   2   5   4   4   2   5   4   2   2   5   5   2
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##   5   1   4   5   2   4   1   5   1   5   5   4   3   4   5   4   2   4   2   5
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##   4   2   4   4   2   1   2   2   2   2   2   2   4   4   1   1   2   3   4   5
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##   5   2   1   4   4   1   5   2   4   4   5   2   4   5   4   2   3   4   4   5
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##   2   4   2   5   2   3   5   2   2   4   2   3   5   4   2   2   2   2   5   3
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##   4   5   4   2   4   4   2   2   2   4   4   5   5   4   4   2   2   4   5   2
##
## Within cluster sum of squares by cluster:
## [1] 416.0750 507.6989 452.8908 550.5556 441.7780
##  (between_SS / total_SS =  40.7 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
perc.var.5 <- round(100*(1 - kmeans5.num$betweenss/kmeans5.num$totss),1)
names(perc.var.5) <- "Perc. 5 clus"
perc.var.5
```

```
## Perc. 5 clus
##         59.3
```

```
# Computing the percentage of variation accounted for. Six clusters
(kmeans6.num <- kmeans(matstd.num,6,nstart = 10))
```

```
## K-means clustering with 6 clusters of sizes 6, 39, 107, 172, 166, 10
##
## Cluster means:
##      Severity Distance.mi. Temperature.F.  Humidity... Pressure.in.
## 1  0.3743416   6.70831691    -0.3958477  0.002130805   -0.3831819
## 2 -0.2608534  -0.22001382    -0.1216707 -0.829591959   -3.0212702
## 3  1.4461919   0.01938662     0.2930756 -0.100668833    0.2974282
## 4 -0.6178428  -0.11510118     0.6152846 -0.618210029    0.2721188
## 5 -0.2557514  -0.13382650    -0.7590297  0.831538521    0.2413979
## 6  0.1908408   0.82688707    -0.4068876  1.140959724    0.1427323
##   Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1    -0.09061981     -0.06205071       0.07692563
## 2     0.91111568     -0.10506978      -0.14749422
## 3     0.17411628     -0.01951409      -0.17737121
## 4     0.22824898      0.31311561      -0.21246627
## 5    -0.48307310     -0.29207316      -0.00341745
## 6    -1.26889254      0.11862939       6.13809348
##
## Clustering vector:
##   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##   4   4   3   5   4   5   5   3   5   3   4   3   4   4   2   6   5   5   4   5
##  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##   3   4   5   4   2   3   5   5   5   4   3   6   5   3   4   2   3   3   5   4
##  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##   4   5   5   2   5   5   5   3   4   5   4   5   4   5   4   2   4   3   2   3
##  61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##   2   5   4   4   5   3   5   2   3   4   5   5   3   3   5   5   4   5   2   1
##  81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##   4   4   5   5   4   3   5   6   5   3   4   3   4   5   3   3   4   5   2   4
## 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##   4   4   2   4   4   4   3   4   3   2   2   4   4   3   4   5   5   2   5   4
## 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##   5   5   3   4   4   4   2   5   4   5   4   5   5   4   5   4   1   5   5   4
## 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##   2   5   5   3   4   4   5   4   4   5   3   4   5   4   2   2   4   3   5   5
## 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##   5   3   4   4   5   5   2   3   5   5   4   4   4   5   4   3   4   4   5   5
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##   2   4   2   5   3   3   5   3   4   3   5   4   4   3   3   4   3   3   4   3
## 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##   5   5   4   5   5   3   3   4   5   4   3   4   2   3   3   4   4   5   3   4
## 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
##   2   4   4   1   4   5   5   5   5   5   4   5   5   5   4   5   4   2   4   4
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##   4   4   4   3   4   2   5   4   5   3   3   4   3   5   2   3   5   4   4   5
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##   5   4   4   3   3   5   3   3   4   5   2   3   6   3   4   5   3   5   5   4
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
```

```
##     5   5   4   4   5   3   3   5   4   2   4   4   4   4   4   4   5   5   5   5
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##     3   5   6   5   3   5   5   4   5   4   2   3   5   3   3   4   5   5   3   2
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##     3   5   5   3   4   3   5   3   4   5   4   4   5   5   4   2   4   4   3   3
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##     1   4   3   5   4   5   3   5   4   5   4   3   4   4   3   3   5   5   3   3
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
##     5   5   4   5   4   4   4   5   4   4   4   4   6   5   3   3   3   5   3   5
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##     5   4   5   4   4   5   4   4   5   5   4   4   5   3   4   5   5   3   3   5
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##     3   2   4   3   5   4   2   3   2   3   3   4   6   4   3   4   5   4   4   3
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##     4   5   4   3   5   2   5   4   5   5   4   5   4   4   2   2   5   1   4   3
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##     3   5   2   4   4   2   3   5   4   4   5   5   3   5   3   5   6   4   4   3
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##     5   4   5   5   5   6   3   5   5   4   5   1   3   4   4   5   5   4   5   6
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##     4   3   4   5   4   4   4   5   5   4   4   3   3   4   4   5   5   4   3   5
##
## Within cluster sum of squares by cluster:
## [1]  83.39929 433.56834 321.26540 484.60073 663.93247 113.61006
##  (between_SS / total_SS =  47.4 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"      "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
perc.var.6 <- round(100*(1 - kmeans6.num$betweenss/kmeans6.num$totss),1)
names(perc.var.6) <- "Perc. 6 clus"
perc.var.6
```

```
## Perc. 6 clus
##         52.6
```

```r
# Computing the percentage of variation accounted for. Seven clusters
(kmeans7.num <- kmeans(matstd.num,7,nstart = 10))
```

```
## K-means clustering with 7 clusters of sizes 149, 115, 12, 10, 114, 64, 36
##
## Cluster means:
##      Severity Distance.mi. Temperature.F. Humidity... Pressure.in.
## 1 -0.5801087  -0.18488754    -0.51774848  0.71735931   0.26045732
## 2  1.4354547  -0.03825598    -0.18625016  0.35355089   0.32930384
## 3  0.2214243   4.77380390     0.08429905 -0.03386252   0.02608219
## 4  0.1908408   0.82688707    -0.40688757  1.14095972   0.14273235
## 5 -0.3661001  -0.15176808     0.86834199 -0.97347784   0.20572274
## 6 -0.5144903  -0.13288908     0.14990304 -0.30313761   0.17807339
## 7 -0.2373277  -0.21667704    -0.19345008 -0.78252376  -3.14631893
##    Visibility.mi. Wind_Speed.mph. Precipitation.in.
```

```
## 1     -0.28630855     -0.44910686     -0.05534099
## 2     -0.17746808     -0.10177788     -0.10583616
## 3      0.06005446     -0.06922055     -0.07192427
## 4     -1.26889254      0.11862939      6.13809348
## 5      0.23112072     -0.25450445     -0.22077417
## 6      0.21745525      1.71383032     -0.15379171
## 7      0.96589378     -0.06683060     -0.14138756
##
## Clustering vector:
##    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##    6   5   2   1   6   1   1   2   1   2   5   2   5   5   7   4   1   1   6   1
##   21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##    2   5   1   5   7   2   1   1   1   5   2   4   1   2   1   7   2   2   3   1
##   41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##    5   1   2   7   1   2   1   5   5   1   6   1   1   1   6   7   5   2   7   5
##   61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##    7   1   6   6   1   2   2   7   2   5   6   1   2   2   6   2   5   1   7   3
##   81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##    5   6   2   1   6   2   1   4   1   2   5   2   5   1   2   2   5   2   7   5
##  101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##    5   5   6   6   5   6   2   5   2   7   7   1   5   2   5   1   2   7   1   1
##  121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##    6   1   2   5   1   6   7   1   5   1   6   1   1   6   1   5   3   6   1   5
##  141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##    7   1   1   2   5   5   1   5   5   2   2   5   1   5   7   7   5   2   1   1
##  161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##    1   2   5   6   1   2   7   2   1   2   6   5   5   1   6   2   6   6   1   1
##  181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##    7   6   7   1   3   6   1   6   6   2   1   5   1   2   2   6   2   5   6   2
##  201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##    1   2   5   1   1   2   5   5   1   5   2   3   7   2   2   5   5   1   6   6
##  221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
##    5   3   5   3   6   2   1   1   1   1   5   1   1   1   5   1   5   7   1   1
##  241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##    1   5   6   2   5   7   1   1   1   2   2   5   5   2   7   6   2   1   5   2
##  261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##    1   1   6   2   2   1   2   6   6   1   7   2   4   2   1   2   2   1   1   6
##  281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
##    6   1   6   5   1   2   5   1   5   7   5   5   6   5   5   5   2   1   1   1
##  301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##    2   2   4   1   5   1   1   6   2   6   7   2   1   2   2   5   1   2   6   5
##  321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##    2   1   1   2   5   2   1   2   6   1   5   5   1   1   5   7   5   6   2   5
##  341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##    3   5   2   1   5   1   2   1   6   1   5   3   5   6   5   2   1   1   2   2
##  361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
##    1   1   5   1   5   6   6   1   5   6   5   1   4   2   2   2   2   1   2   2
##  381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##    1   5   1   5   3   2   5   5   1   2   5   5   1   2   5   1   1   2   2   1
##  401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##    2   7   5   2   1   6   7   2   7   2   2   6   4   5   2   5   1   5   1   2
##  421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##    6   1   6   5   1   7   6   1   1   1   1   1   5   5   7   7   1   3   6   2
##  441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
```

```
##    2    1    7    5    5    7    2    6    5    6    2    1    5    2    5    1    4    5    5    2
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##    1    5    1    2    1    4    2    1    1    5    1    3    2    6    5    1    1    1    2    4
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##    5    2    6    6    5    5    1    1    1    5    5    2    2    6    5    1    1    5    2    1
##
## Within cluster sum of squares by cluster:
## [1] 435.1724 393.6987 145.0910 113.6101 218.7422 213.0439 410.8366
##  (between_SS / total_SS =  51.6 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"      "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
perc.var.7 <- round(100*(1 - kmeans7.num$betweenss/kmeans7.num$totss),1)
names(perc.var.7) <- "Perc. 7 clus"
perc.var.7
```

```
## Perc. 7 clus
##         48.4
```

```r
# Computing the percentage of variation accounted for. nine clusters
(kmeans9.num <- kmeans(matstd.num,9,nstart = 10))
```

```
## K-means clustering with 9 clusters of sizes 124, 10, 6, 34, 51, 138, 65, 68, 4
##
## Cluster means:
##        Severity Distance.mi. Temperature.F.  Humidity... Pressure.in.
## 1 -0.6023561  -0.08516217      0.8282891 -0.831521130    0.2257714
## 2  0.1908408   0.82688707     -0.4068876  1.140959724    0.1427323
## 3  0.3743416   6.70831691     -0.3958477  0.002130805   -0.3831819
## 4 -0.3272790  -0.21259279     -0.2576174 -0.657605737   -3.0097296
## 5 -0.5791428  -0.07604851     -0.4314103 -0.061386834    0.1601000
## 6 -0.5697566  -0.19017656     -0.4453709  0.739837550    0.2981513
## 7  1.4047690   0.02233057     -0.6647676  0.856224807    0.3343610
## 8  1.4267725  -0.01345174      0.5897004 -0.534381518    0.2853177
## 9  0.3743416  -0.28610927     -0.2328782 -1.059672391   -3.8095333
##   Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1    0.22878186     -0.07870325      -0.21213127
## 2   -1.26889254      0.11862939       6.13809348
## 3   -0.09061981     -0.06205071       0.07692563
## 4    0.11893137     -0.13037512      -0.11570365
## 5    0.03447782      1.86638459      -0.11570365
## 6   -0.24831306     -0.54486185      -0.06286384
## 7   -0.47343178     -0.12836626      -0.01742231
## 8    0.21579340      0.01639583      -0.22077417
## 9    7.35699377      0.15304465      -0.22077417
##
## Clustering vector:
##    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20
##    1    1    8    6    5    6    6    8    6    8    1    8    1    1    4    2    6    6    1    6
##   21   22   23   24   25   26   27   28   29   30   31   32   33   34   35   36   37   38   39   40
```

```
##   8   1   6   1   4   8   6   6   6   1   8   2   6   7   6   4   8   8   6   6
##  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##   1   6   7   4   6   7   6   8   1   6   1   6   6   6   5   9   1   7   4   8
##  61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##   4   6   5   5   6   7   7   4   7   1   5   6   8   7   5   7   1   6   4   3
##  81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##   1   5   7   6   5   8   6   2   6   7   1   8   1   6   7   7   1   7   4   1
## 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##   1   1   5   1   1   1   8   1   8   4   4   6   1   8   1   6   7   4   6   6
## 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##   5   6   8   1   1   5   4   6   1   6   5   6   6   1   6   1   3   5   6   1
## 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##   4   6   6   8   1   1   6   1   1   7   8   1   6   1   4   4   1   7   6   6
## 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##   5   7   1   5   6   7   4   7   6   7   5   1   1   6   5   8   5   5   6   6
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##   4   5   4   5   7   8   6   5   1   8   6   1   6   7   8   5   8   8   5   8
## 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##   5   7   1   6   6   8   8   1   6   1   7   1   4   8   7   1   1   6   5   5
## 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
##   1   1   1   3   5   7   6   6   6   6   1   6   6   6   1   6   1   9   6   6
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##   1   1   5   8   1   9   6   6   6   8   7   1   8   7   4   8   7   6   1   7
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##   6   1   1   7   8   6   8   8   1   6   9   8   2   8   6   7   7   6   5   1
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
##   5   6   1   1   6   7   8   4   1   4   1   1   5   1   1   1   7   6   6   6
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##   8   7   2   6   8   6   6   5   7   5   4   8   6   7   8   1   6   7   8   1
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##   7   5   6   8   1   7   6   7   5   4   1   1   6   6   1   4   1   1   7   8
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##   3   1   8   6   1   6   8   6   5   6   1   8   1   5   8   7   6   6   8   7
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
##   5   6   1   6   1   5   1   6   1   1   1   6   2   7   7   7   7   6   7   7
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##   6   1   6   1   1   7   1   1   6   7   1   1   6   8   1   6   6   8   8   6
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##   7   4   1   8   6   5   4   8   4   8   8   5   2   1   8   1   6   1   6   7
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##   5   6   5   8   6   4   5   6   6   6   6   6   1   1   4   4   6   3   1   7
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##   8   6   4   1   1   4   8   5   1   1   7   6   8   7   8   5   2   1   1   7
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##   6   1   6   7   6   2   8   6   6   1   6   3   8   5   1   6   6   6   7   2
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##   1   7   5   5   1   1   6   6   6   1   1   7   8   5   1   6   6   1   7   6
##
## Within cluster sum of squares by cluster:
## [1] 250.36466 113.61006  83.39929 179.46177 199.22258 353.07040 224.68787
## [8] 152.04291  57.42334
##  (between_SS / total_SS =  59.6 %)
##
## Available components:
```

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```
##
## [1] "cluster"      "centers"      "totss"      "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"       "ifault"
```

```
perc.var.9 <- round(100*(1 - kmeans9.num$betweenss/kmeans9.num$totss),1)
names(perc.var.9) <- "Perc. 9 clus"
perc.var.9
```

```
## Perc. 9 clus
##         40.4
```

```
# Computing the percentage of variation accounted for. ten clusters
(kmeans10.num <- kmeans(matstd.num,10,nstart = 10))
```

```
## K-means clustering with 10 clusters of sizes 96, 35, 8, 96, 55, 4, 51, 7, 115, 33
##
## Cluster means:
##        Severity Distance.mi. Temperature.F.  Humidity... Pressure.in.
## 1   -0.46670363  -0.08373242     0.87768023 -1.062821807    0.19339608
## 2   -0.33344712  -0.21013380    -0.29371012 -0.608316049   -2.97569649
## 3    0.37434157   6.31879532    -0.47930387  0.219890444   -0.26850890
## 4    1.46387740   0.06231273     0.29775845 -0.002818278    0.31919043
## 5    0.19084080  -0.10589224    -1.07687868  1.159414485    0.24698057
## 6    0.37434157  -0.28610927    -0.23287818 -1.059672391   -3.80953332
## 7   -0.61512337  -0.15293349     0.44074977 -0.478062544    0.23422267
## 8   -0.01887437  -0.24935445    -0.23813527  1.221790457    0.21277893
## 9   -0.59103205  -0.19851669    -0.08773703  0.587538822    0.37029042
## 10   0.01290066  -0.05443549    -1.49362185  0.320180946    0.08257993
##    Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1       0.2268724    -0.262806373       -0.22077417
## 2       0.1227841    -0.149317966       -0.11870567
## 3      -0.2466753    -0.085711197        1.43145970
## 4       0.1596071    -0.192900382       -0.17239795
## 5      -1.6414298     0.002868981        0.20791354
## 6       7.3569938     0.153044647       -0.22077417
## 7       0.2284551     1.713540361       -0.21376947
## 8      -1.3495186     0.204667532        6.71988394
## 9       0.1302443    -0.649728626       -0.12136832
## 10      0.1285428     1.054098644       -0.06921791
##
## Clustering vector:
##    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##    7   1   4   9  10   5  10   4   9   4   1   4   1   1   2   8   9   9   7   9
##   21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##    4   1   9   1   2   4   9   9   9   1   4   8   5   4   9   2   4   4   9   9
##   41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##    1  10   5   2   9   5   9   1   1   9   7   9   9   5   7   6   1  10   2   4
##   61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##    2   9  10   7   5   4   5   2   4   1  10   9   4   4  10   5   9   9   2   3
##   81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##    1   7   5   9   7   4   5   3   5  10   1   4   9   5   4  10   1   5   2   9
##  101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##    1   1  10   7   1   7   4   1   4   2   2   9   9   4   1   9   5   2   9   9
```

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```
## 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
## 10   9   4   9  10   7   2   9   7   9   7   9   9   7   5   1   3  10   9   1
## 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##   2   9   5   4   1   1   5   1   1   5   4   1   9   1   2   2   1   4   5   9
## 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
## 10   4   1   7   5   5   2  10   9   5   7   1   1   9   7   4   7   7   5   9
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##   2   7   2  10   4   4  10   7   7   4   5   1   9   4   4   7   4   4   7   4
## 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##   5   5   9  10   5   4   4   1   9   1   4   1   2   4   4   1   1   5   7   7
## 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
##   1   1   7   3   7   5   9   9   5   5   1   9   9   9   9   9   1   6   9   9
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##   9   1   7   4   1   6   9   9   9   4   4   1   4  10   2   4   5   9   9   5
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##   9   9   7   4   4   9   4   4   7   9   6   4   8   4   9   5  10   9   5   7
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
## 10  10   7   1   9   4   1   2   1   2   1   1   7   1   1   1  10   9  10   9
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##   4   4   8   9   4   9   9   7   5   7   2   4   9   4   4   1   9  10   7   1
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##   4  10   9   4   1   4   5   4   7   2   1   1   9   5   1   2   1   7   4   4
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##   3   1   4   9   1   9   4   9   7   9   9   4   1   7   4  10   9   5   4   4
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
## 10   9   1   9   1   7   7   9   1   7   1   9   8   5   4   4   4   5   4   5
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##   9   1   9   1   1   5   1   1   9   4   1   1   9   4   1   9   9   4   4   9
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##   4   2   1   4   9  10   2   4   2   4   4   7   3   1   4   1   9   1   9   4
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##   7   9   7   1   9   2  10   9   9   5   9   5   1   1   2   2   9   3   7   4
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##   4   2   2   1   9   2   4  10   1   7   5   5   1   5   4   5   8   1   1   4
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##   9   1   5  10   9   8   4   9   5   1   9   3   4   7   9   9   5   9   5   5
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##   1   4   7  10   1   1   9   9   9   1   1   4   4   7   1   5   9   1   4   9
##
## Within cluster sum of squares by cluster:
##  [1] 180.70262 185.78922 138.76397 254.56009 191.38862  57.42334 137.29726
##  [8]  46.64630 180.59779 105.38141
##  (between_SS / total_SS =  63.0 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
perc.var.10<- round(100*(1 - kmeans10.num$betweenss/kmeans10.num$totss),1)
names(perc.var.10) <- "Perc. 10 clus"
perc.var.10
```

```
## Perc. 10 clus
```

```
# Computing the percentage of variation accounted for. twelve clusters
(kmeans12.num <- kmeans(matstd.num,12,nstart = 10))
```

```
## K-means clustering with 12 clusters of sizes 9, 4, 5, 33, 115, 54, 1, 34, 50, 52, 92, 51
##
## Cluster means:
##        Severity Distance.mi. Temperature.F. Humidity... Pressure.in.
## 1    0.06850695   0.95055333    -0.34736573  1.14431910   0.18227478
## 2    0.83309350  -0.28610927     0.12197480 -1.07047039  -3.80360195
## 3   -0.17616074   7.24676722    -0.08673133 -0.09001212  -0.41560673
## 4    0.01290066  -0.05443549    -1.49362185  0.32018095   0.08257993
## 5   -0.59103205  -0.19851669    -0.08773703  0.58753882   0.37029042
## 6    1.59768005   0.21341075    -0.09531789  0.59482095   0.39873295
## 7   -0.54316228  -0.28610927    -0.67973009 -1.04887439  -3.72451710
## 8   -0.38124984  -0.20789923    -0.32410401 -0.59408810  -2.95437016
## 9   -0.65326274  -0.15026998     0.41794847 -0.46319095   0.24095574
## 10   0.12732130  -0.09580825    -1.09908342  1.17136024   0.22531519
## 11  -0.54316228  -0.07610161     0.85510906 -1.02493100   0.19310596
## 12   1.32782597  -0.07237667     0.72318904 -0.74568353   0.22460843
##     Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1      -1.20847934      0.12436527        6.44770127
## 2       4.77400640      0.19606372       -0.22077417
## 3      -0.15949947     -0.01903164        0.13646559
## 4       0.12854276      1.05409864       -0.06921791
## 5       0.13024433     -0.64972863       -0.12136832
## 6       0.03374625     -0.43551998       -0.13477201
## 7      13.16871534      0.06700651       -0.22077417
## 8       0.04296116     -0.16074152       -0.11570365
## 9       0.22794864      1.70517273       -0.21362937
## 10     -1.68122674      0.03788590        0.23264552
## 11      0.22570256     -0.27901646       -0.22077417
## 12      0.23858447      0.10749504       -0.22077417
##
## Clustering vector:
##    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##    9  11  12   5   4  10   4  12   5  12  11   6  11  11   8   1   5   5   9   5
##   21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##    6  11   5  11   2  12   5   5   5  11  12   1  10   6   5   8   6  12   5   5
##   41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##   11   4  10   8   5  10   5  12  11   5   9   5   5  10   9   2  11   4   8  12
##   61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##    8   5   4   9  10   6  10   8   6  11   4   5   6   6   4  10   5   5   8   3
##   81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##   11   9  10   5   9  12  10   1  10   4  11   6   5  10   6   4  11  10   8   5
##  101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##   11  11   4   9  11   9   6  11   6   8   8   5   5  12  11   5   6   8   5   5
##  121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##    4   5  12   5   4   9   8   5   9   5   9   5   5   9  10  11   3   4   5  11
##  141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##    8   5  10  12  11  11  10  11  11  10  12  11   5  11   8   8  11   6  10   5
##  161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##    4   6  11   9  10  10   8   4   5  10   9  11  11   5   9  12   9   9  10   5
```

```
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
##   8   9   8   4   6  12   4   9   9   6  10  11   5   6  12   9  12  12   9   6
## 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##  10  10   5   4  10   6  12  11   5  11   6  11   8  12   6  11  11  10   9   9
## 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
##  11  11   9   3   9  10   5   5  10  10  11   5   5   5   5   5  11   2   5   5
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##   5  11   9  12  11   2   5   5   5  12   6  11  12   4   8  12  10   5   5  10
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##   5   5   9   6  12   5   6  12   9   5   7   6   1  12   5  10   4   5  10   9
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
##   4   4   9  11   5   6  12   8  11   8  11  11   9  11  11  11   4   5   4   5
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##  12   6   1   5  12   5   5   9  10   9   8  12   5   6  12  11   5   4  12  11
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##   6   4   5  12  11   6  10   6   9   8  11  11   5  10  11   8  11   9   6  12
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##   6  11   6   5  11   5  12   5   9   5   5  12  11   9  12   4   5  10   6   6
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
##   4   5  11   5  11   9   9   5  11   9  11   5   1  10   6   6   6  10   6  10
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##   5  11   5  11  11  10  11  11   5   6  11  11   5  12  11   5   5  12  12   5
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##   6   8  11  12   5   4   8  12   8  12  12   9   1  11   6  11   5  11   5   6
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##   9   5   9  12   5   8   4   5   5  10   5  10  11  11   8   8   5   3   9   6
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##   6   8   8  11   5   8  12   4  11   9  10  10  12   6  12  10   1  11  11   6
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
##   5  11  10   4   5   1  12   5  10  11   5   3   6   9   5   5  10   5   6  10
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##  11   6   9   4  11  11   5   5   5  11  11   6  12   9  11  10   5  11   6   5
##
## Within cluster sum of squares by cluster:
##  [1] 101.46760  16.79062  62.15281 105.38141 180.59779 142.70698   0.00000
##  [8] 173.43423 131.38535 181.13044 158.43653 103.36376
##  (between_SS / total_SS =  66.0 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
perc.var.12 <- round(100*(1 - kmeans12.num$betweenss/kmeans12.num$totss),1)
names(perc.var.12) <- "Perc. 12 clus"
perc.var.12
```

```
## Perc. 12 clus
##            34
```

```r
# Computing the percentage of variation accounted for. fifteen clusters
(kmeans15.num <- kmeans(matstd.num,15,nstart = 10))
```

```
## K-means clustering with 15 clusters of sizes 53, 40, 42, 4, 8, 49, 51, 47, 52, 15, 28, 16, 67, 21, 7
```

```
## 
## Cluster means:
##       Severity Distance.mi. Temperature.F. Humidity... Pressure.in.
## 1   1.56882772  0.141662554     -0.0604856   0.5973111   0.41042712
## 2  -0.72666305 -0.175460984      0.6542543  -0.4517451   0.27954915
## 3  -0.54316228 -0.064107068      1.2816619  -1.2473519   0.14913445
## 4   0.37434157 -0.286109267     -0.2328782  -1.0596724  -3.80953332
## 5   0.37434157  6.318795315     -0.4793039   0.2198904  -0.26850890
## 6  -0.61806056  0.008826541      0.4789735   0.5897770   0.37788875
## 7   1.32782597 -0.072376673      0.7231890  -0.7456835   0.22460843
## 8  -0.58220500 -0.239371355      0.1949587  -0.8264816   0.32311312
## 9   0.12732130 -0.095808248     -1.0990834   1.1713602   0.22531519
## 10 -0.42082843 -0.034253472     -0.3327627  -0.4384275   0.13429663
## 11  0.11219761 -0.063486737     -1.5901439   0.3163011   0.04557095
## 12 -0.31378632 -0.250997367     -1.2810088   0.4871409  -3.06267571
## 13 -0.54316228 -0.236139937     -0.3870597   0.6394813   0.35578931
## 14 -0.36839964 -0.182746036      0.6295335  -1.5774621  -2.77625202
## 15 -0.01887437 -0.249354450     -0.2381353   1.2217905   0.21277893
##    Visibility.mi. Wind_Speed.mph. Precipitation.in.
## 1       0.0295947     -0.43850816      -0.133149323
## 2       0.2344061      1.18980426      -0.220774169
## 3       0.1922788     -0.09687567      -0.220774169
## 4       7.3569938      0.15304465      -0.220774169
## 5      -0.2466753     -0.08571120       1.431459701
## 6       0.1114506     -0.09804626      -0.002055951
## 7       0.2385845      0.10749504      -0.220774169
## 8       0.2372914     -0.54075229      -0.220774169
## 9      -1.6812267      0.03788590       0.232645521
## 10      0.1676789      3.02098272      -0.101694250
## 11      0.1338541      0.96917788      -0.131464230
## 12     -0.1942084     -0.41695804       0.002500678
## 13      0.1573984     -0.94747308      -0.194114486
## 14      0.3767779     -0.05590513      -0.220774169
## 15     -1.3495186      0.20466753       6.719883942
## 
## Clustering vector:
##   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20
##   2   3   7   6   2   9  11   7  13   7   8   1   3   3  12  15  13  13   2  13
##  21  22  23  24  25  26  27  28  29  30  31  32  33  34  35  36  37  38  39  40
##   1   8  13   6  14   7   6  13  13   3   7  15   9   1   6  14   1   7   6   6
##  41  42  43  44  45  46  47  48  49  50  51  52  53  54  55  56  57  58  59  60
##   2  11   9  14  13   9  13   7   3  13   2  13   6   9   2   4   3  11  12   7
##  61  62  63  64  65  66  67  68  69  70  71  72  73  74  75  76  77  78  79  80
##  12  13  11   2   9   1   9  14   1   3  10   6   1   1  10   9   6  13  14   5
##  81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96  97  98  99 100
##   3   2   9   6   2   7   9   5   9  11   6   1   6   9   1  11   3   9  12   6
## 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120
##   3   3  11   2   3   2   1   8   1  14  14   8   6   7   3  13   1  14  13   6
## 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140
##  11  13   7   8   8  10  14  13   2   6   2  13  13   2   9   8   5  11  13   8
## 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160
##  14  13   9   7   3   3   9   3   3   9   7   8  13   3  14  14   3   1   9  13
## 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180
##  11   1   8  10   9   9  14  11  13   9   2   3   3  13   2   7   6  10   9   6
```

43

```
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200
## 12  10  12  11   1   7  11  10   2   1   9   3   6   1   7  10   7   7  10   1
## 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220
##  9   9   6  11   9   1   7   8   8   6   1   6  14   7   1   8   8   9  10   2
## 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240
## 14   3   2   5  10   9  13  13   9   9   3  13  13  13   8  13   8   4   8   8
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260
##  6   8   2   7   8   4  13   6  13   7   1   6   7  11  12   7   9   6   6   9
## 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280
##  6   6   2   1   7  13   1   7   2  13   4   1  15   7   6   9  11  13   9   2
## 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300
## 11  11   2   8  13   1   7  12   8  14   3   3   2   8   8   8  11  13   6  13
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320
##  7   1  15   6   7  13  13   2   9   2  12   7  13   1   7   3  13  11   7  14
## 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340
##  1  11   6   7   3   1   9   1  10  12   3   6  13   9   3  14   3   2   1   7
## 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360
##  5   2   1  13   3   6   7  13  10   6   6   7   3   2   7  11  13   9   1   1
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380
## 11  13   8  13   8   2   2   6   3   2   8   6  15   9   1   1   1   9   1   9
## 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400
##  6   8   6   8   6   9   2   8   6   1   3   8  13   7   8  13  13   7   7  13
## 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420
##  1  12   8   7  13  11  12   7  14   7   7  10   5   8   1   3  13   8   6   1
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440
##  2  13   2   7  13  14  11   6  13   9   8   9   8   8  14  12  13   5   2   1
## 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460
##  1  12  12   8   6  12   7  11   8   2   9   9   7   1   7   9  15   8   8   1
## 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480
## 13   3   9  11  13  15   7  13   9   3  13   5   1   2   6  13   9   8   1   9
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500
##  8   1   2  11   3   3   8  13   6   3   8   1   7  10   3   9  13   6   1  13
##
## Within cluster sum of squares by cluster:
##  [1] 121.62749  62.46288  60.03897  57.42334 138.76397  91.40352 103.36376
##  [8]  43.43998 181.13044  43.54383  82.30302  53.86346  69.90284  71.31594
## [15]  46.64630
##  (between_SS / total_SS =  69.3 %)
##
## Available components:
##
## [1] "cluster"      "centers"      "totss"        "withinss"     "tot.withinss"
## [6] "betweenss"    "size"         "iter"         "ifault"
```

```r
perc.var.15 <- round(100*(1 - kmeans15.num$betweenss/kmeans15.num$totss),1)
names(perc.var.15) <- "Perc. 15 clus"
perc.var.15
```

```
## Perc. 15 clus
##          30.7
```

```r
# Saving four k-means clusters in a list
clus1 <- matrix(names(kmeans4.num$cluster[kmeans4.num$cluster == 1]),
```

```
                ncol=1, nrow=length(kmeans4.num$cluster[kmeans4.num$cluster == 1]))
colnames(clus1) <- "Cluster 1"
clus2 <- matrix(names(kmeans4.num$cluster[kmeans4.num$cluster == 2]),
                ncol=1, nrow=length(kmeans4.num$cluster[kmeans4.num$cluster == 2]))
colnames(clus2) <- "Cluster 2"
clus3 <- matrix(names(kmeans4.num$cluster[kmeans4.num$cluster == 3]),
                ncol=1, nrow=length(kmeans4.num$cluster[kmeans4.num$cluster == 3]))
colnames(clus3) <- "Cluster 3"
clus4 <- matrix(names(kmeans4.num$cluster[kmeans4.num$cluster == 4]),
                ncol=1, nrow=length(kmeans4.num$cluster[kmeans4.num$cluster == 4]))
colnames(clus4) <- "Cluster 4"
list(clus1,clus2,clus3,clus4)
```

```
## [[1]]
##        Cluster 1
##  [1,] "15"
##  [2,] "25"
##  [3,] "36"
##  [4,] "44"
##  [5,] "56"
##  [6,] "59"
##  [7,] "61"
##  [8,] "68"
##  [9,] "79"
## [10,] "99"
## [11,] "103"
## [12,] "110"
## [13,] "111"
## [14,] "118"
## [15,] "127"
## [16,] "141"
## [17,] "155"
## [18,] "156"
## [19,] "167"
## [20,] "181"
## [21,] "183"
## [22,] "213"
## [23,] "221"
## [24,] "238"
## [25,] "246"
## [26,] "255"
## [27,] "271"
## [28,] "290"
## [29,] "311"
## [30,] "320"
## [31,] "330"
## [32,] "336"
## [33,] "402"
## [34,] "407"
## [35,] "409"
## [36,] "426"
## [37,] "435"
## [38,] "436"
```

```
## [39,] "443"
## [40,] "446"
## [41,] "472"
##
## [[2]]
##         Cluster 2
##  [1,] "16"
##  [2,] "32"
##  [3,] "88"
##  [4,] "273"
##  [5,] "303"
##  [6,] "373"
##  [7,] "413"
##  [8,] "457"
##  [9,] "466"
## [10,] "480"
##
## [[3]]
##         Cluster 3
##  [1,] "4"
##  [2,] "6"
##  [3,] "7"
##  [4,] "9"
##  [5,] "10"
##  [6,] "12"
##  [7,] "17"
##  [8,] "18"
##  [9,] "20"
## [10,] "21"
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```r
# Comparing the effect of number of  clusters
fviz_cluster(kmeans2.num,geom = "point",data=matstd.num)+ggtitle("K=2")
```

K=2
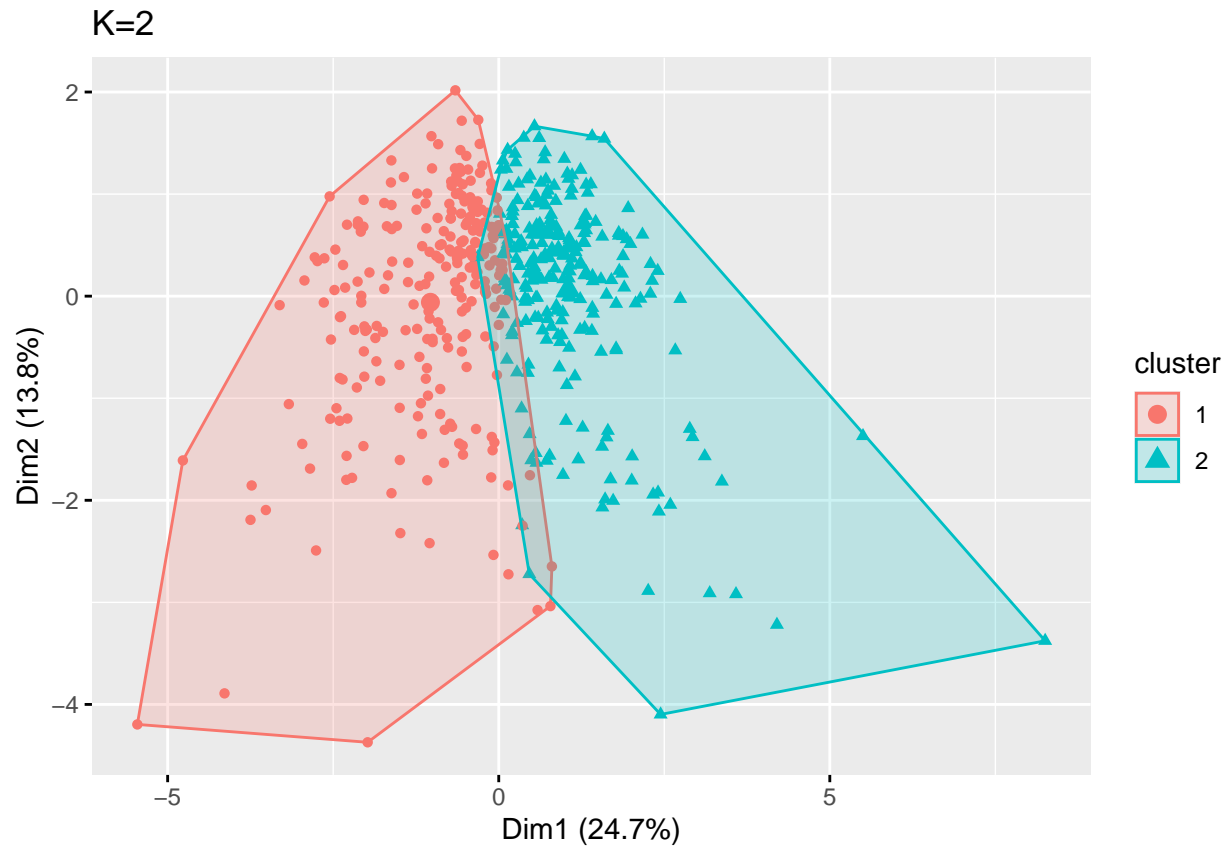
```r
fviz_cluster(kmeans3.num,geom = "point",data=matstd.num)+ggtitle("K=3")
```
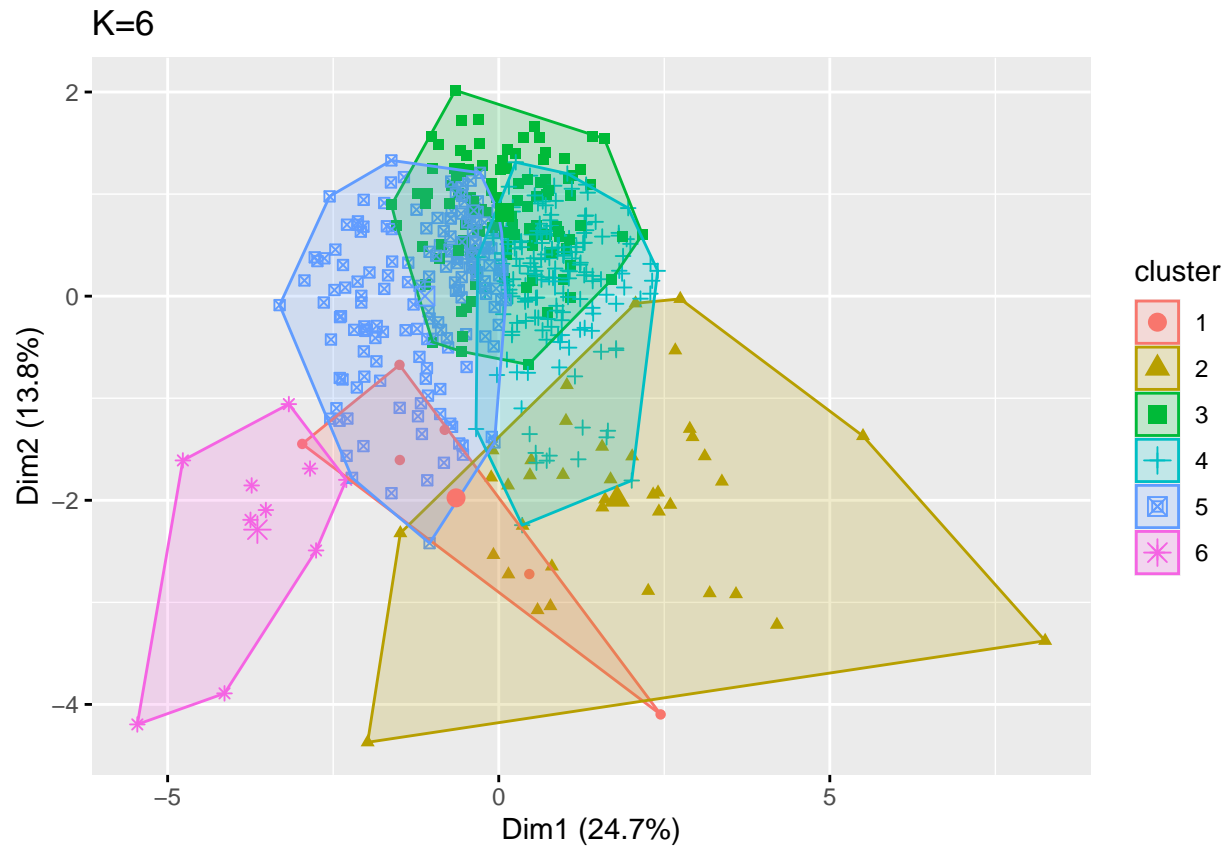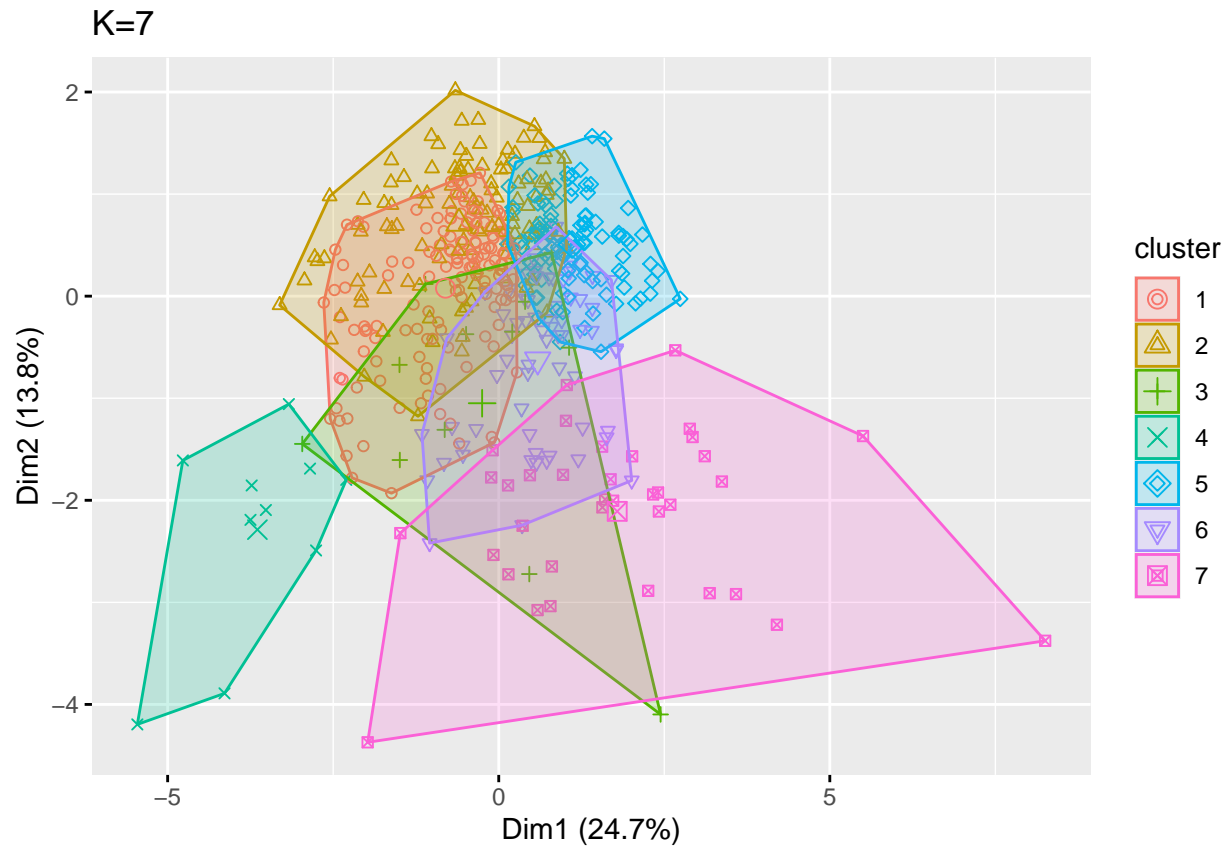
K=3
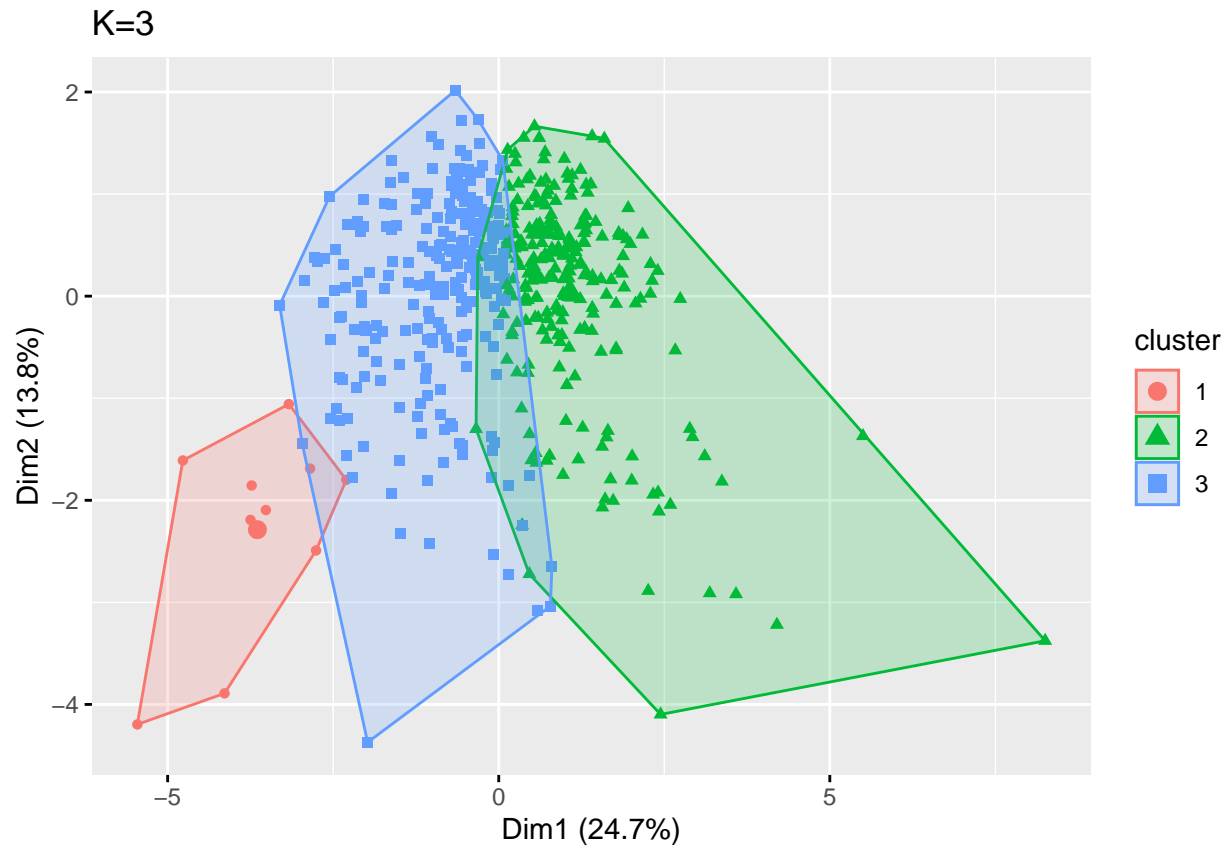
```
fviz_cluster(kmeans4.num,geom = "point",data=matstd.num)+ggtitle("K=4")
```
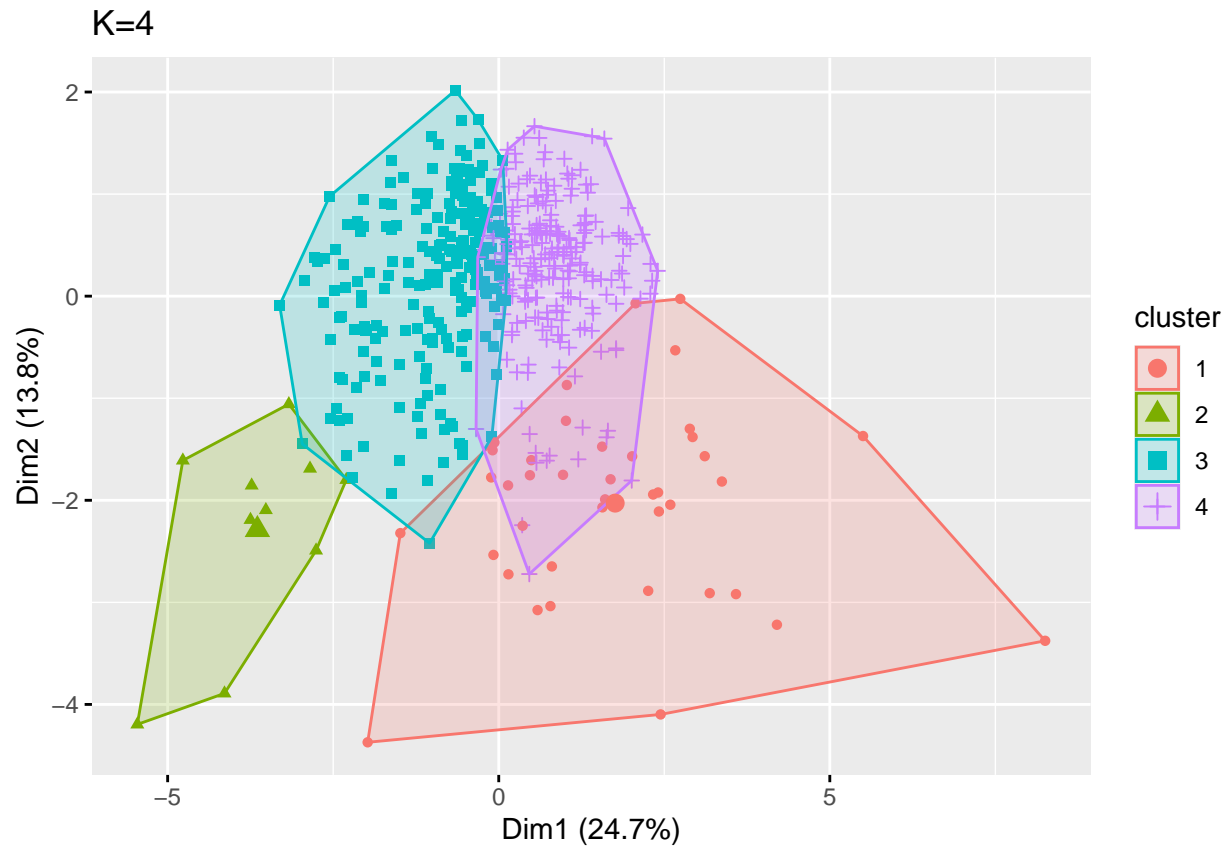
```r
fviz_cluster(kmeans5.num,geom = "point",data=matstd.num)+ggtitle("K=5")
```
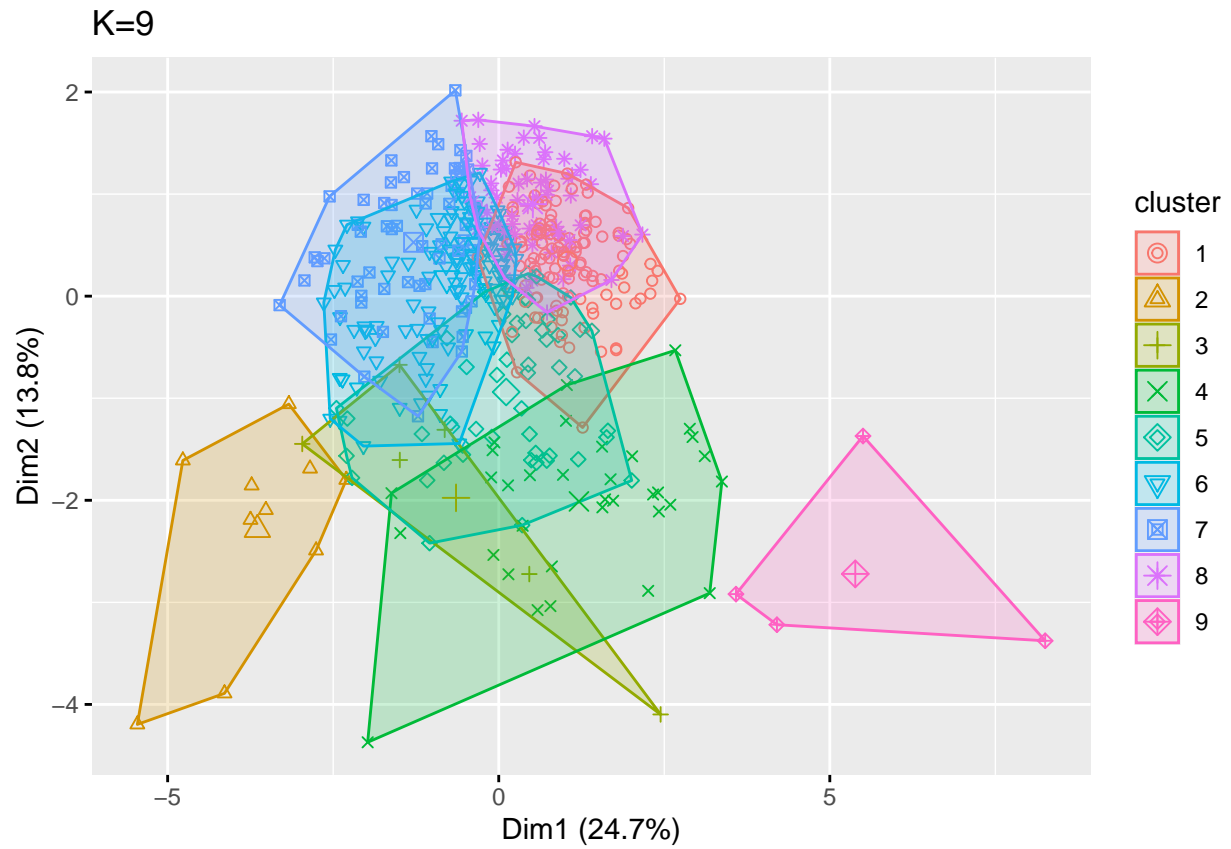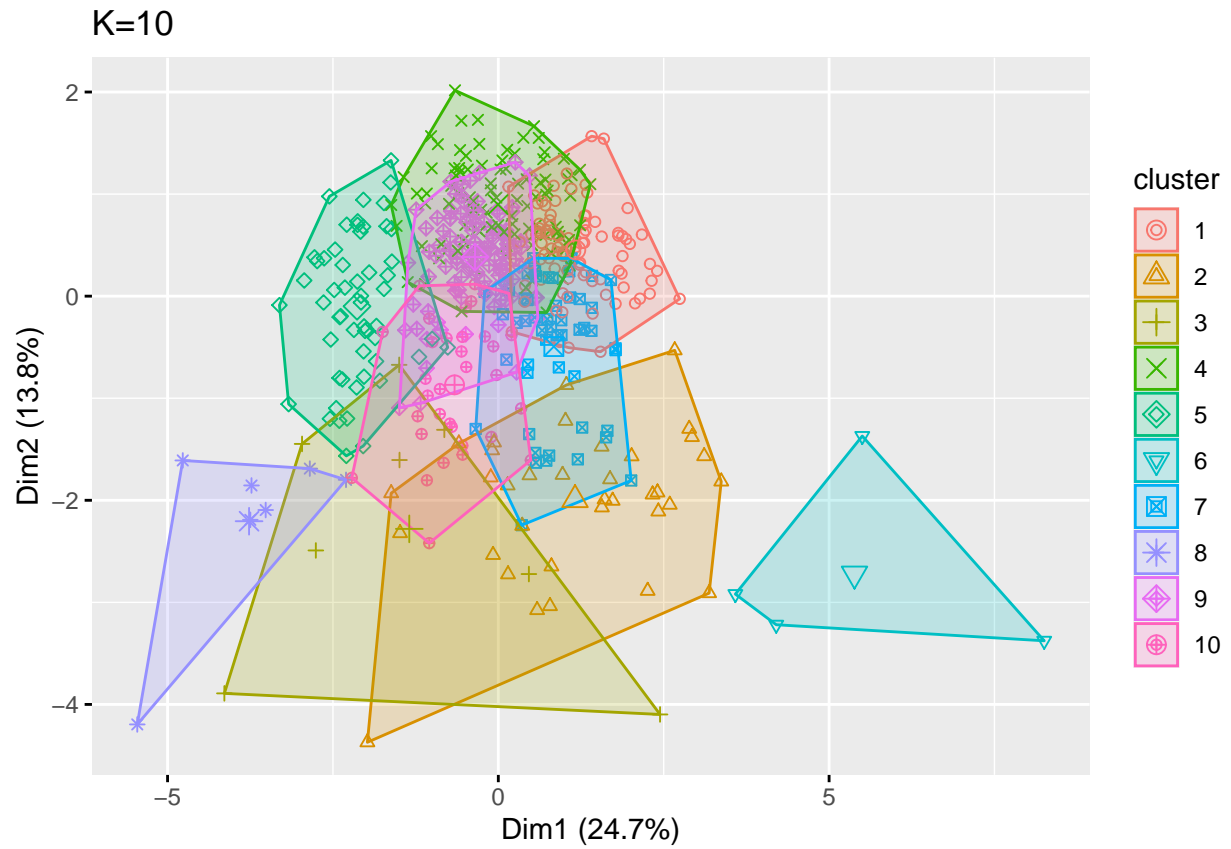
K=5
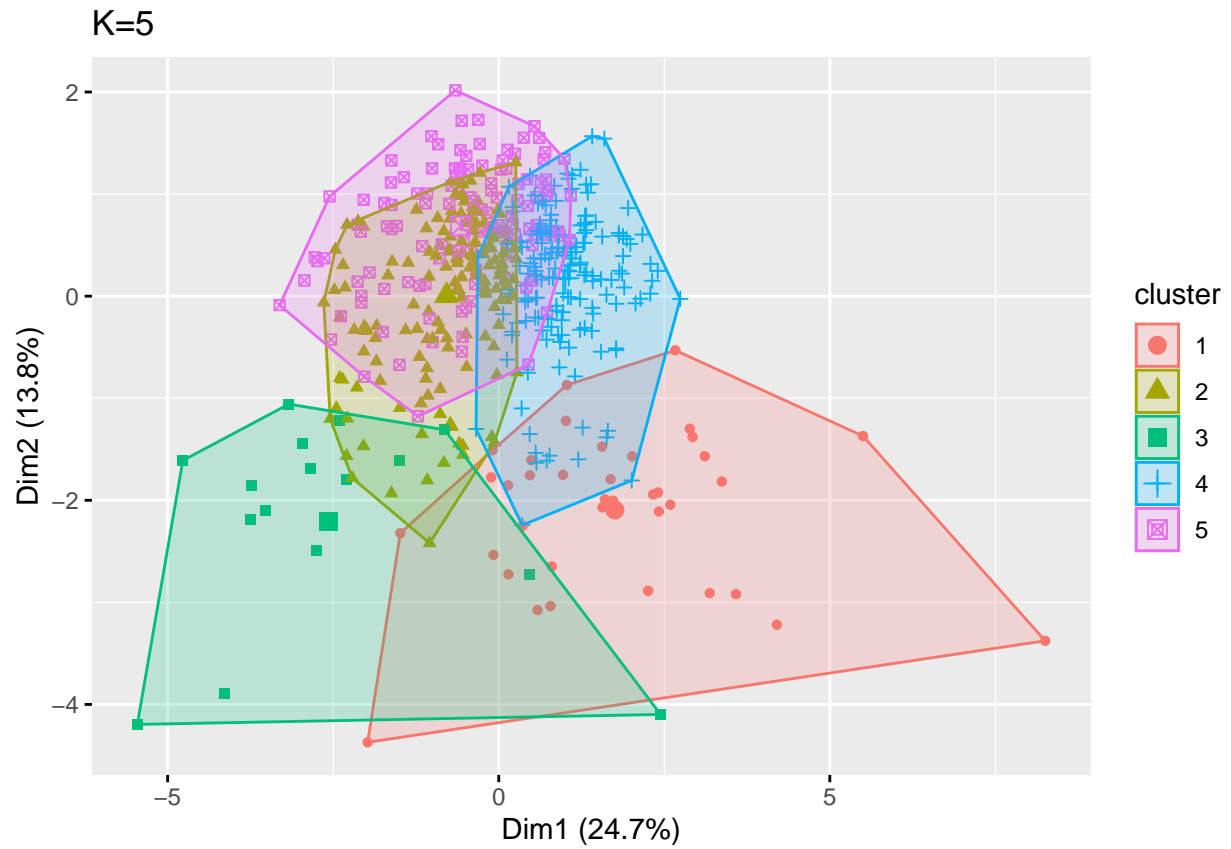
```r
fviz_cluster(kmeans6.num,geom = "point",data=matstd.num)+ggtitle("K=6")
```

K=6

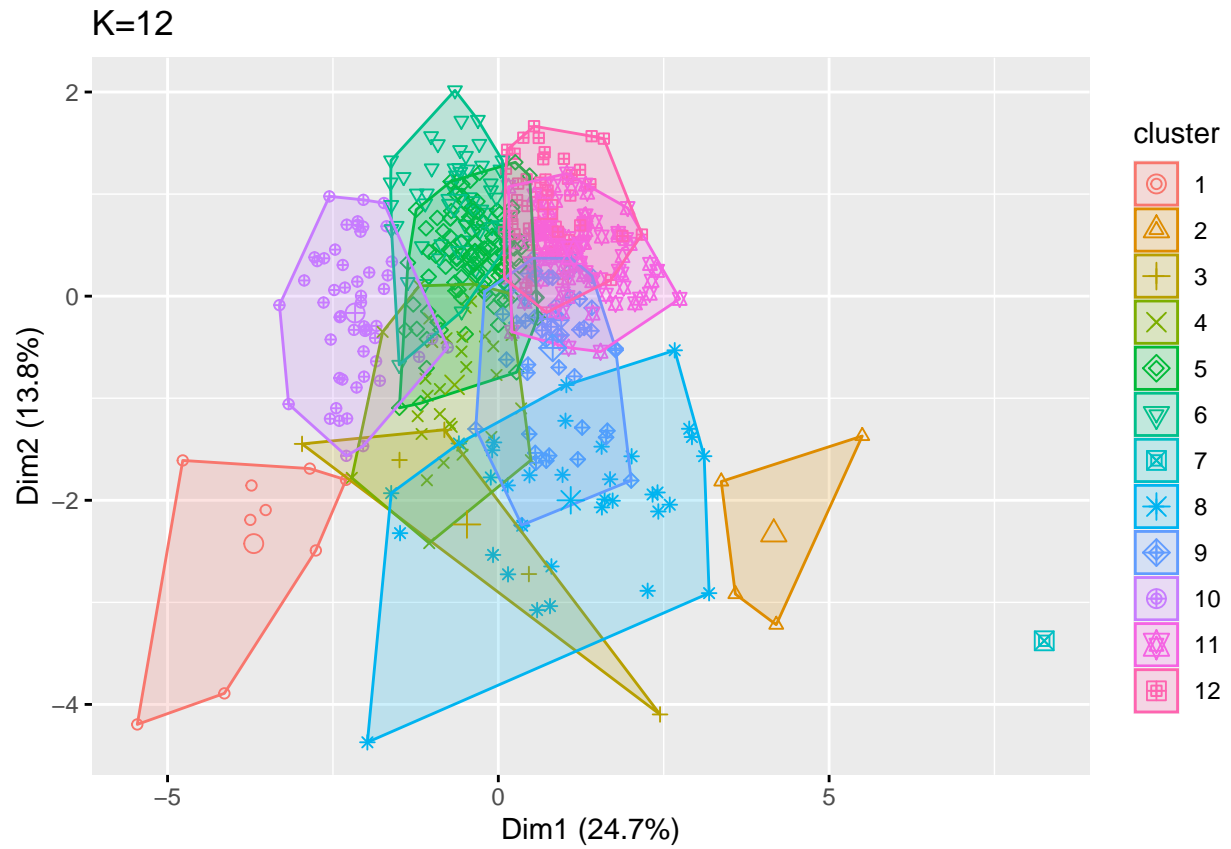fviz_cluster(kmeans7.num,geom = "point",data=matstd.num)+ggtitle("K=7")

K=7

```
fviz_cluster(kmeans9.num,geom = "point",data=matstd.num)+ggtitle("K=9")
```

```
fviz_cluster(kmeans10.num,geom = "point",data=matstd.num)+ggtitle("K=10")
```

K=10

```
fviz_cluster(kmeans12.num,geom = "point",data=matstd.num)+ggtitle("K=12")
```

K=12

```
fviz_cluster(kmeans15.num,geom = "point",data=matstd.num)+ggtitle("K=15")
```

K=15