ACADGILD

SESSION 10: Correlations

Assignment 1

PROBLEM STATEMENT

1 Import dataset from the following link:
https://archive.ics.uci.edu/ml/machine-learning-databases/00360/
Perform the below written operations:

a) Read the file in Zip format and get it into R
b) Create Univariate for all the columns.
c) Check for missing values in all columns.
d) Impute the missing values using appropriate methods
e) Create bi-variate analysis for all relationships
f) Test relevant hypothesis for valid relations
g) Create cross tabulations with derived variables
h) check for trends and patterns in time series
i) Find out the most polluted time of the day and the name of the chemical compound

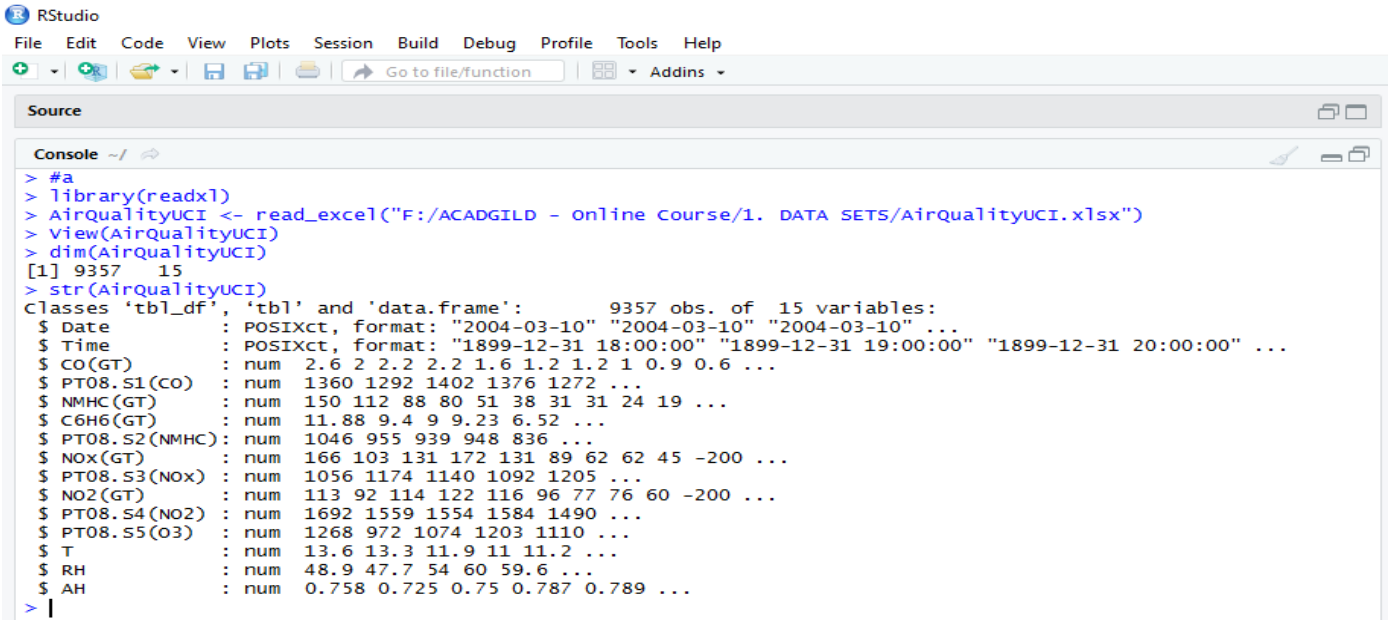
SOLUTION

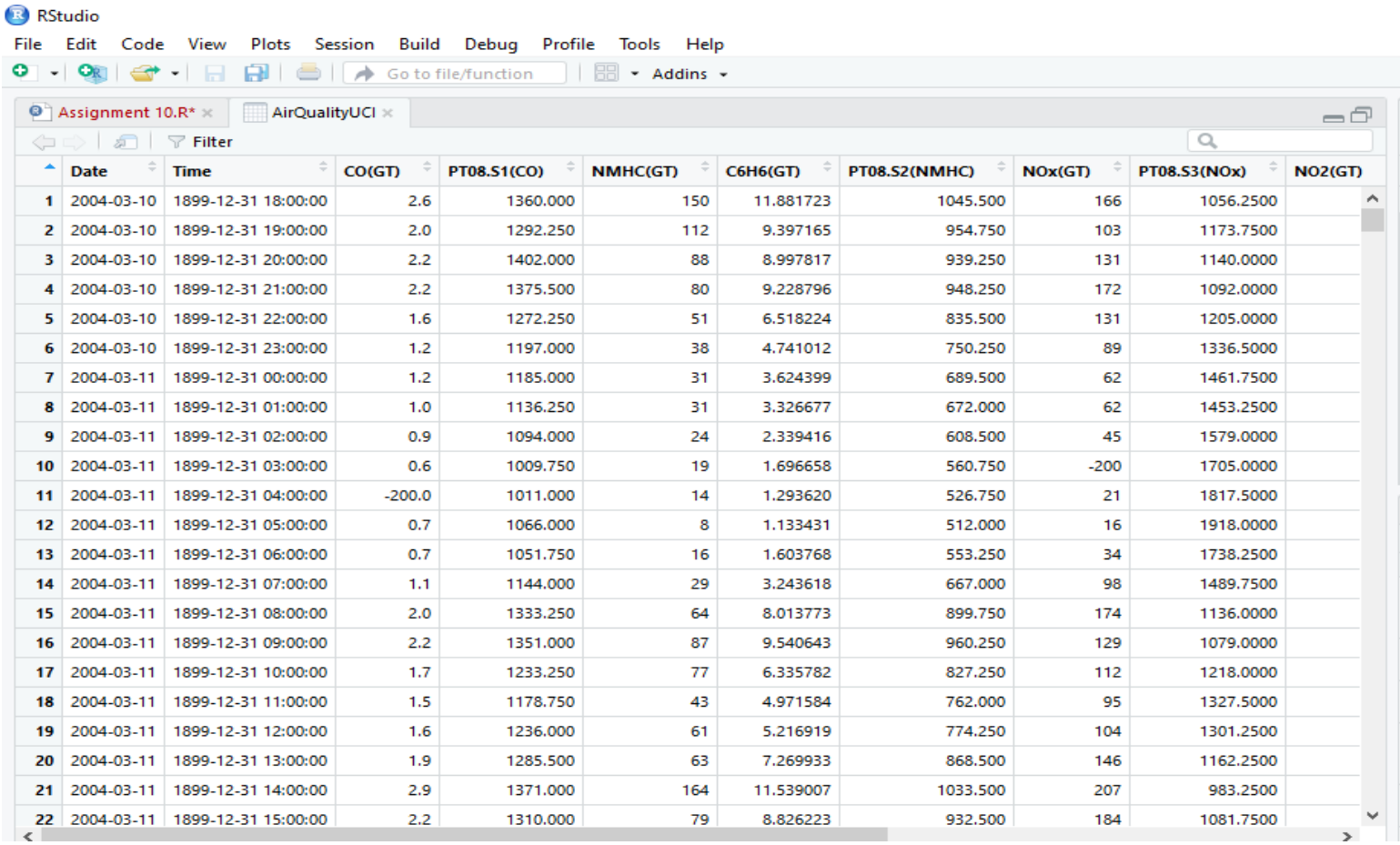
a) Read the file in Zip format and get it into R

The R-script for the given problem is as follows:

```
library(readxl)
#AirQualityUCI <-read_excel(unzip("F:/ACADGILD - Online Course/1. DATA SETS/AirQualityUCI.zip"))
AirQualityUCI <- read_excel(" F:/ACADGILD - Online Course/1. DATA SETS/AirQualityUCI.xlsx ")
AirQualityUCI <- read_excel("F:/ACADGILD - Online Course/1. DATA SETS/AirQualityUCI.xlsx")
View(AirQualityUCI)
dim(AirQualityUCI)
str(AirQualityUCI)
```

The output of the R-Script (from Console window) is given as follows:





	Date	Time	CO(GT)	PT08.S1(CO)	NMHC(GT)	C6H6(GT)	PT08.S2(NMHC)	NOx(GT)	PT08.S3(NOx)	NO2(GT)
1	2004-03-10	1899-12-31 18:00:00	2.6	1360.000	150	11.881723	1045.500	166	1056.2500	
2	2004-03-10	1899-12-31 19:00:00	2.0	1292.250	112	9.397165	954.750	103	1173.7500	
3	2004-03-10	1899-12-31 20:00:00	2.2	1402.000	88	8.997817	939.250	131	1140.0000	
4	2004-03-10	1899-12-31 21:00:00	2.2	1375.500	80	9.228796	948.250	172	1092.0000	
5	2004-03-10	1899-12-31 22:00:00	1.6	1272.250	51	6.518224	835.500	131	1205.0000	
6	2004-03-10	1899-12-31 23:00:00	1.2	1197.000	38	4.741012	750.250	89	1336.5000	
7	2004-03-11	1899-12-31 00:00:00	1.2	1185.000	31	3.624399	689.500	62	1461.7500	
8	2004-03-11	1899-12-31 01:00:00	1.0	1136.250	31	3.326677	672.000	62	1453.2500	
9	2004-03-11	1899-12-31 02:00:00	0.9	1094.000	24	2.339416	608.500	45	1579.0000	
10	2004-03-11	1899-12-31 03:00:00	0.6	1009.750	19	1.696658	560.750	-200	1705.0000	
11	2004-03-11	1899-12-31 04:00:00	-200.0	1011.000	14	1.293620	526.750	21	1817.5000	
12	2004-03-11	1899-12-31 05:00:00	0.7	1066.000	8	1.133431	512.000	16	1918.0000	
13	2004-03-11	1899-12-31 06:00:00	0.7	1051.750	16	1.603768	553.250	34	1738.2500	
14	2004-03-11	1899-12-31 07:00:00	1.1	1144.000	29	3.243618	667.000	98	1489.7500	
15	2004-03-11	1899-12-31 08:00:00	2.0	1333.250	64	8.013773	899.750	174	1136.0000	
16	2004-03-11	1899-12-31 09:00:00	2.2	1351.000	87	9.540643	960.250	129	1079.0000	
17	2004-03-11	1899-12-31 10:00:00	1.7	1233.250	77	6.335782	827.250	112	1218.0000	
18	2004-03-11	1899-12-31 11:00:00	1.5	1178.750	43	4.971584	762.000	95	1327.5000	
19	2004-03-11	1899-12-31 12:00:00	1.6	1236.000	61	5.216919	774.250	104	1301.2500	
20	2004-03-11	1899-12-31 13:00:00	1.9	1285.500	63	7.269933	868.500	146	1162.2500	
21	2004-03-11	1899-12-31 14:00:00	2.9	1371.000	164	11.539007	1033.500	207	983.2500	
22	2004-03-11	1899-12-31 15:00:00	2.2	1310.000	79	8.826223	932.500	184	1081.7500	

Conclusion/Interpretation:

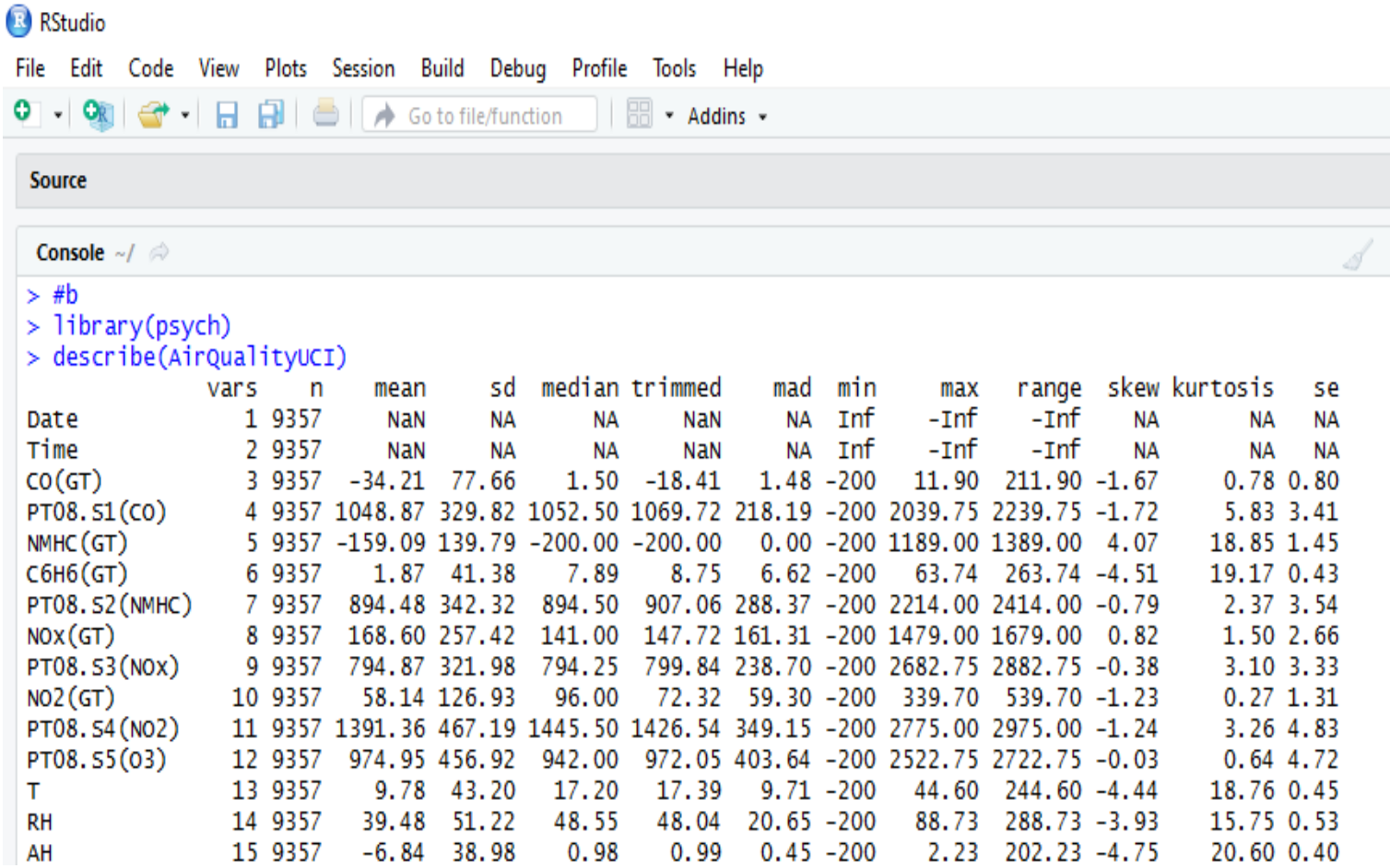
The file is read from Zip format and is viewed with name AirQualityUCI.

b) Create Univariate for all the columns.

The R-script for the given problem is as follows:

```
library(psych)
describe(Air)
```

The output of the R-Script (from Console window) is given as follows:



	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
Date	1	9357	NaN	NA	NA	NaN	NA	Inf	-Inf	-Inf	NA	NA	NA
Time	2	9357	NaN	NA	NA	NaN	NA	Inf	-Inf	-Inf	NA	NA	NA
CO(GT)	3	9357	-34.21	77.66	1.50	-18.41	1.48	-200	11.90	211.90	-1.67	0.78	0.80
PT08.S1(CO)	4	9357	1048.87	329.82	1052.50	1069.72	218.19	-200	2039.75	2239.75	-1.72	5.83	3.41
NMHC(GT)	5	9357	-159.09	139.79	-200.00	-200.00	0.00	-200	1189.00	1389.00	4.07	18.85	1.45
C6H6(GT)	6	9357	1.87	41.38	7.89	8.75	6.62	-200	63.74	263.74	-4.51	19.17	0.43
PT08.S2(NMHC)	7	9357	894.48	342.32	894.50	907.06	288.37	-200	2214.00	2414.00	-0.79	2.37	3.54
NOx(GT)	8	9357	168.60	257.42	141.00	147.72	161.31	-200	1479.00	1679.00	0.82	1.50	2.66
PT08.S3(NOx)	9	9357	794.87	321.98	794.25	799.84	238.70	-200	2682.75	2882.75	-0.38	3.10	3.33
NO2(GT)	10	9357	58.14	126.93	96.00	72.32	59.30	-200	339.70	539.70	-1.23	0.27	1.31
PT08.S4(NO2)	11	9357	1391.36	467.19	1445.50	1426.54	349.15	-200	2775.00	2975.00	-1.24	3.26	4.83
PT08.S5(O3)	12	9357	974.95	456.92	942.00	972.05	403.64	-200	2522.75	2722.75	-0.03	0.64	4.72
T	13	9357	9.78	43.20	17.20	17.39	9.71	-200	44.60	244.60	-4.44	18.76	0.45
RH	14	9357	39.48	51.22	48.55	48.04	20.65	-200	88.73	288.73	-3.93	15.75	0.53
AH	15	9357	-6.84	38.98	0.98	0.99	0.45	-200	2.23	202.23	-4.75	20.60	0.40

Conclusion/Interpretation:

Univariate for all the columns is created using describe() function

c) Check for missing values in all columns.

The R-script for the given problem is as follows:

```
col1<- mapply(anyNA,AirQualityUCI)
col1
summary(AirQualityUCI)
is.na(AirQualityUCI)
```

The output of the R-Script (from Console window) is given as follows:

```
#c
> col1<- mapply(anyNA,AirQualityUCI)
> col1
         Date          Time        CO(GT)   PT08.S1(CO)      NMHC(GT)
C6H6(GT) PT08.S2(NMHC)
        FALSE         FALSE         FALSE         FALSE         FALSE
FALSE         FALSE
      NOx(GT)  PT08.S3(NOx)       NO2(GT)  PT08.S4(NO2)   PT08.S5(O3)
T            RH
        FALSE         FALSE         FALSE         FALSE         FALSE
FALSE         FALSE
           AH
        FALSE
> summary(AirQualityUCI)
      Date                          Time                          CO(GT)
PT08.S1(CO)
 Min.   :2004-03-10 00:00:00   Min.   :1899-12-31 00:00:00   Min.   :-200.00
Min.   :-200
 1st Qu.:2004-06-16 00:00:00   1st Qu.:1899-12-31 05:00:00   1st Qu.:   0.60
1st Qu.: 921
 Median :2004-09-21 00:00:00   Median :1899-12-31 11:00:00   Median :   1.50
Median :1052
 Mean   :2004-09-21 04:30:05   Mean   :1899-12-31 11:29:55   Mean   : -34.21
Mean   :1049
 3rd Qu.:2004-12-28 00:00:00   3rd Qu.:1899-12-31 18:00:00   3rd Qu.:   2.60
3rd Qu.:1221
 Max.   :2005-04-04 00:00:00   Max.   :1899-12-31 23:00:00   Max.   :  11.90
Max.   :2040
    NMHC(GT)          C6H6(GT)        PT08.S2(NMHC)       NOx(GT)
PT08.S3(NOx)       NO2(GT)
 Min.   :-200.0   Min.   :-200.000   Min.   :-200.0   Min.   :-200.0   Min.
:-200.0   Min.   :-200.00
 1st Qu.:-200.0   1st Qu.:   4.005   1st Qu.: 711.0   1st Qu.:  50.0   1st
Qu.: 637.0   1st Qu.:  53.00
 Median :-200.0   Median :   7.887   Median : 894.5   Median : 141.0   Median
: 794.2   Median :  96.00
 Mean   :-159.1   Mean   :   1.866   Mean   : 894.5   Mean   : 168.6   Mean
: 794.9   Mean   :  58.14
 3rd Qu.:-200.0   3rd Qu.:  13.636   3rd Qu.:1104.8   3rd Qu.: 284.2   3rd
Qu.: 960.2   3rd Qu.: 133.00
 Max.   :1189.0   Max.   :  63.741   Max.   :2214.0   Max.   :1479.0   Max.
:2682.8   Max.   : 339.70
  PT08.S4(NO2)   PT08.S5(O3)           T                   RH
AH
 Min.   :-200   Min.   :-200.0   Min.   :-200.000   Min.   :-200.00   Min.
:-200.0000
 1st Qu.:1185   1st Qu.: 699.8   1st Qu.:  10.950   1st Qu.:  34.05   1st
Qu.:   0.6923
 Median :1446   Median : 942.0   Median :  17.200   Median :  48.55   Median
:   0.9768
```

```
 Mean   :1391   Mean   : 975.0   Mean   :   9.777   Mean   :  39.48   Mean
:  -6.8376
 3rd Qu.:1662   3rd Qu.:1255.2   3rd Qu.:  24.075   3rd Qu.:  61.88   3rd
Qu.:   1.2962
 Max.   :2775   Max.   :2522.8   Max.   :  44.600   Max.   :  88.72   Max.
:   2.2310
> is.na(AirQualityUCI)
         Date  Time CO(GT) PT08.S1(CO) NMHC(GT) C6H6(GT) PT08.S2(NMHC)
NOx(GT) PT08.S3(NOx) NO2(GT)
   [1,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
   [2,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
   [3,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
   [4,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
   [5,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
   [6,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
   [7,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
   [8,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
   [9,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [10,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [11,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [12,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [13,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [14,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [15,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [16,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [17,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [18,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [19,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [20,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
```

```
 [21,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [22,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [23,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [24,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [25,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [26,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [27,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [28,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [29,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [30,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [31,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [32,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [33,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [34,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [35,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [36,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [37,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [38,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [39,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [40,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [41,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [42,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [43,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [44,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
 [45,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
```

```
  [46,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [47,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [48,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [49,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [50,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [51,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [52,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [53,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [54,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [55,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [56,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [57,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [58,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [59,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [60,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [61,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [62,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [63,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [64,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [65,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
  [66,] FALSE FALSE  FALSE       FALSE    FALSE    FALSE         FALSE
FALSE        FALSE   FALSE
       PT08.S4(NO2) PT08.S5(O3)     T    RH    AH
   [1,]        FALSE       FALSE FALSE FALSE FALSE
   [2,]        FALSE       FALSE FALSE FALSE FALSE
   [3,]        FALSE       FALSE FALSE FALSE FALSE
   [4,]        FALSE       FALSE FALSE FALSE FALSE
   [5,]        FALSE       FALSE FALSE FALSE FALSE
   [6,]        FALSE       FALSE FALSE FALSE FALSE
   [7,]        FALSE       FALSE FALSE FALSE FALSE
```

```
 [8,]       FALSE       FALSE FALSE FALSE FALSE
 [9,]       FALSE       FALSE FALSE FALSE FALSE
[10,]       FALSE       FALSE FALSE FALSE FALSE
[11,]       FALSE       FALSE FALSE FALSE FALSE
[12,]       FALSE       FALSE FALSE FALSE FALSE
[13,]       FALSE       FALSE FALSE FALSE FALSE
[14,]       FALSE       FALSE FALSE FALSE FALSE
[15,]       FALSE       FALSE FALSE FALSE FALSE
[16,]       FALSE       FALSE FALSE FALSE FALSE
[17,]       FALSE       FALSE FALSE FALSE FALSE
[18,]       FALSE       FALSE FALSE FALSE FALSE
[19,]       FALSE       FALSE FALSE FALSE FALSE
[20,]       FALSE       FALSE FALSE FALSE FALSE
[21,]       FALSE       FALSE FALSE FALSE FALSE
[22,]       FALSE       FALSE FALSE FALSE FALSE
[23,]       FALSE       FALSE FALSE FALSE FALSE
[24,]       FALSE       FALSE FALSE FALSE FALSE
[25,]       FALSE       FALSE FALSE FALSE FALSE
[26,]       FALSE       FALSE FALSE FALSE FALSE
[27,]       FALSE       FALSE FALSE FALSE FALSE
[28,]       FALSE       FALSE FALSE FALSE FALSE
[29,]       FALSE       FALSE FALSE FALSE FALSE
[30,]       FALSE       FALSE FALSE FALSE FALSE
[31,]       FALSE       FALSE FALSE FALSE FALSE
[32,]       FALSE       FALSE FALSE FALSE FALSE
[33,]       FALSE       FALSE FALSE FALSE FALSE
[34,]       FALSE       FALSE FALSE FALSE FALSE
[35,]       FALSE       FALSE FALSE FALSE FALSE
[36,]       FALSE       FALSE FALSE FALSE FALSE
[37,]       FALSE       FALSE FALSE FALSE FALSE
[38,]       FALSE       FALSE FALSE FALSE FALSE
[39,]       FALSE       FALSE FALSE FALSE FALSE
[40,]       FALSE       FALSE FALSE FALSE FALSE
[41,]       FALSE       FALSE FALSE FALSE FALSE
[42,]       FALSE       FALSE FALSE FALSE FALSE
[43,]       FALSE       FALSE FALSE FALSE FALSE
[44,]       FALSE       FALSE FALSE FALSE FALSE
[45,]       FALSE       FALSE FALSE FALSE FALSE
[46,]       FALSE       FALSE FALSE FALSE FALSE
[47,]       FALSE       FALSE FALSE FALSE FALSE
[48,]       FALSE       FALSE FALSE FALSE FALSE
[49,]       FALSE       FALSE FALSE FALSE FALSE
[50,]       FALSE       FALSE FALSE FALSE FALSE
[51,]       FALSE       FALSE FALSE FALSE FALSE
[52,]       FALSE       FALSE FALSE FALSE FALSE
[53,]       FALSE       FALSE FALSE FALSE FALSE
[54,]       FALSE       FALSE FALSE FALSE FALSE
[55,]       FALSE       FALSE FALSE FALSE FALSE
[56,]       FALSE       FALSE FALSE FALSE FALSE
[57,]       FALSE       FALSE FALSE FALSE FALSE
```

```
 [58,]        FALSE       FALSE FALSE FALSE FALSE
 [59,]        FALSE       FALSE FALSE FALSE FALSE
 [60,]        FALSE       FALSE FALSE FALSE FALSE
 [61,]        FALSE       FALSE FALSE FALSE FALSE
 [62,]        FALSE       FALSE FALSE FALSE FALSE
 [63,]        FALSE       FALSE FALSE FALSE FALSE
 [64,]        FALSE       FALSE FALSE FALSE FALSE
 [65,]        FALSE       FALSE FALSE FALSE FALSE
 [66,]        FALSE       FALSE FALSE FALSE FALSE
[ reached getOption("max.print") -- omitted 9291 rows ]
```

```
#or

AirQualityUCI[AirQualityUCI == -200] <- NA
View(AirQualityUCI)
library(VIM)
aggr(AirQualityUCI, col=c('pink','yellow'),
    numbers=TRUE, sortVars=TRUE,
    labels=names(AirQualityUCI), cex.axis=.7,
    gap=3, ylab=c("Missing data","Pattern")) # graphical presentation of NAs

sapply(AirQualityUCI, function(x) sum(is.na(x))) # count of NAs

AirQualityUCI$`NMHC(GT)` <- NULL
```

The output of the R-Script (from Console window) is given as follows:

```
> AirQualityUCI[AirQualityUCI == -200] <- NA


> View(AirQualityUCI)
```

RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function | Addins

Assignment 10.R* | AirQualityUCI

Filter

	Date	Time	CO(GT)	PT08.S1(CO)	C6H6(GT)	PT08.S2(NMHC)	NOx(GT)	PT08.S3(NOx)	NO2(GT)	PT08.S4(NO2)	PT08.S5(O3)	T	RH	AH
1	2004-03-10	1899-12-31 18:00:00	2.6	1360.000	11.881723	1045.500	166	1056.2500	113	1692.000	1267.500	13.600000	48.87500	0.7577538
2	2004-03-10	1899-12-31 19:00:00	2.0	1292.250	9.397165	954.750	103	1173.7500	92	1558.750	972.250	13.300000	47.70000	0.7254874
3	2004-03-10	1899-12-31 20:00:00	2.2	1402.000	8.997817	939.250	131	1140.0000	114	1554.500	1074.000	11.900000	53.97500	0.7502391
4	2004-03-10	1899-12-31 21:00:00	2.2	1375.500	9.228796	948.250	172	1092.0000	122	1583.750	1203.250	11.000000	60.00000	0.7867125
5	2004-03-10	1899-12-31 22:00:00	1.6	1272.250	6.518224	835.500	131	1205.0000	116	1490.000	1110.000	11.150000	59.57500	0.7887942
6	2004-03-10	1899-12-31 23:00:00	1.2	1197.000	4.741012	750.250	89	1336.5000	96	1393.000	949.250	11.175000	59.17500	0.7847717
7	2004-03-11	1899-12-31 00:00:00	1.2	1185.000	3.624399	689.500	62	1461.7500	77	1332.750	732.500	11.325000	56.77500	0.7603119
8	2004-03-11	1899-12-31 01:00:00	1.0	1136.250	3.326677	672.000	62	1453.2500	76	1332.750	729.500	10.675000	60.00000	0.7702385
9	2004-03-11	1899-12-31 02:00:00	0.9	1094.000	2.339416	608.500	45	1579.0000	60	1276.000	619.500	10.650000	59.67500	0.7648187
10	2004-03-11	1899-12-31 03:00:00	0.6	1009.750	1.696658	560.750	NA	1705.0000	NA	1234.750	501.250	10.250000	60.20000	0.7516572
11	2004-03-11	1899-12-31 04:00:00	NA	1011.000	1.293620	526.750	21	1817.5000	34	1196.750	445.250	10.075000	60.47500	0.7464945
12	2004-03-11	1899-12-31 05:00:00	0.7	1066.000	1.133431	512.000	16	1918.0000	28	1182.000	421.750	11.000000	56.17500	0.7365596
13	2004-03-11	1899-12-31 06:00:00	0.7	1051.750	1.603768	553.250	34	1738.2500	48	1221.250	471.500	10.450000	58.12500	0.7352951
14	2004-03-11	1899-12-31 07:00:00	1.1	1144.000	3.243618	667.000	98	1489.7500	82	1339.000	729.750	10.200000	59.60000	0.7417362
15	2004-03-11	1899-12-31 08:00:00	2.0	1333.250	8.013773	899.750	174	1136.0000	112	1517.000	1101.500	10.750000	57.42500	0.7407946
16	2004-03-11	1899-12-31 09:00:00	2.2	1351.000	9.540643	960.250	129	1079.0000	101	1582.750	1027.750	10.500000	60.60000	0.7691108
17	2004-03-11	1899-12-31 10:00:00	1.7	1233.250	6.335782	827.250	112	1218.0000	98	1445.750	859.750	10.800000	58.35000	0.7551831
18	2004-03-11	1899-12-31 11:00:00	1.5	1178.750	4.971584	762.000	95	1327.5000	92	1361.750	670.500	10.500000	57.92500	0.7351608
19	2004-03-11	1899-12-31 12:00:00	1.6	1236.000	5.216919	774.250	104	1301.2500	95	1401.250	664.000	9.525000	66.77500	0.7950538
20	2004-03-11	1899-12-31 13:00:00	1.9	1285.500	7.269933	868.500	146	1162.2500	112	1536.750	799.000	8.300000	76.42500	0.8392681
21	2004-03-11	1899-12-31 14:00:00	2.9	1371.000	11.539007	1033.500	207	983.2500	128	1730.250	1036.500	8.000000	81.15000	0.8735885
22	2004-03-11	1899-12-31 15:00:00	2.2	1310.000	8.826223	932.500	184	1081.7500	126	1646.500	946.250	8.325000	79.80000	0.8777844

Showing 1 to 23 of 9,357 entries

Console

```
> library(VIM)
Loading required package: colorspace
Loading required package: grid
Loading required package: data.table
data.table 1.12.0  Latest news: r-datatable.com
VIM is ready to use.

 Attaching package: 'VIM'

The following object is masked from 'package:datasets':

    sleep

> aggr(AirQualityUCI, col=c('pink','yellow'),
+      numbers=TRUE, sortVars=TRUE,
+      labels=names(AirQualityUCI), cex.axis=.7,
+      gap=3, ylab=c("Missing data","Pattern"))    # graphical presentation
of NAs

 Variables sorted by number of missings:
      Variable     Count
      NMHC(GT) 0.9023191
        CO(GT) 0.1798653
       NO2(GT) 0.1754836
       NOx(GT) 0.1751630
   PT08.S1(CO) 0.0391151
      C6H6(GT) 0.0391151
 PT08.S2(NMHC) 0.0391151
  PT08.S3(NOx) 0.0391151
  PT08.S4(NO2) 0.0391151
   PT08.S5(O3) 0.0391151
```

```
     T 0.0391151
    RH 0.0391151
    AH 0.0391151
  Date 0.0000000
  Time 0.0000000
```


```
> sapply(AirQualityUCI, function(x) sum(is.na(x)))     # count of NAs
        Date           Time        CO(GT)   PT08.S1(CO)       NMHC(GT)
C6H6(GT) PT08.S2(NMHC)
           0              0          1683           366          8443
366           366
      NOx(GT)   PT08.S3(NOx)        NO2(GT)   PT08.S4(NO2)   PT08.S5(O3)
T             RH
         1639           366          1642           366           366
366           366
          AH
         366
> AirQualityUCI$`NMHC(GT)` <- NULL
```

Conclusion/Interpretation:

Variable NMHC(GT) is having 90% of missing values. Hence, NMHC(GT) is not considered and omitted from the data frame

d) Impute the missing values using appropriate methods

The R-script for the given problem is as follows:

```
colSums(is.na(AirQualityUCI))
library(plyr)
AirQualityUCI[AirQualityUCI==-200.0]<-NA
for(i in 1:ncol(AirQualityUCI)){ AirQualityUCI[is.na(AirQualityUCI[,i]),i] <-
mean(AirQualityUCI[,i], na.rm = TRUE)} summary(AirQualityUCI)
```

The output of the R-Script (from Console window) is given as follows:

```
> AirQualityUCI[AirQualityUCI==-200.0]<-NA
> for(i in 1:ncol(AirQualityUCI)){
+   AirQualityUCI[is.na(AirQualityUCI[,i]),i] <- mean(AirQualityUCI[,i], na.rm = TRUE)}
> summary(AirQualityUCI)
      Date                 Time               CO(GT)
 Min.   :2004-03-10   Min.   :1899-12-31 00:00:00   Min.   : 0.100
 1st Qu.:2004-06-16   1st Qu.:1899-12-31 05:00:00   1st Qu.: 1.200
 Median :2004-09-21   Median :1899-12-31 11:00:00   Median : 2.153
 Mean   :2004-09-21   Mean   :1899-12-31 11:29:55   Mean   : 2.153
 3rd Qu.:2004-12-28   3rd Qu.:1899-12-31 18:00:00   3rd Qu.: 2.600
 Max.   :2005-04-04   Max.   :1899-12-31 23:00:00   Max.   :11.900
  PT08.S1(CO)       NMHC(GT)       C6H6(GT)       PT08.S2(NMHC)
 Min.   : 647.2   Min.   :   7.0   Min.   : 0.149   Min.   : 383.2
 1st Qu.: 941.2   1st Qu.: 218.8   1st Qu.: 4.591   1st Qu.: 742.5
 Median :1074.5   Median : 218.8   Median : 8.593   Median : 923.2
 Mean   :1099.7   Mean   : 218.8   Mean   :10.083   Mean   : 939.0
 3rd Qu.:1221.2   3rd Qu.: 218.8   3rd Qu.:13.636   3rd Qu.:1104.8
 Max.   :2039.8   Max.   :1189.0   Max.   :63.741   Max.   :2214.0

    NOx(GT)         PT08.S3(NOx)      NO2(GT)        PT08.S4(NO2)   PT08.S5(O3)
 Min.   :   2.0   Min.   : 322.0   Min.   :  2.0   Min.   : 551   Min.   : 221.0
 1st Qu.: 112.0   1st Qu.: 665.5   1st Qu.: 85.9   1st Qu.:1242   1st Qu.: 741.8
 Median : 229.0   Median : 817.5   Median :113.1   Median :1456   Median : 982.5
 Mean   : 246.9   Mean   : 835.4   Mean   :113.1   Mean   :1456   Mean   :1022.8
 3rd Qu.: 284.2   3rd Qu.: 960.2   3rd Qu.:133.0   3rd Qu.:1662   3rd Qu.:1255.2
 Max.   :1479.0   Max.   :2682.8   Max.   :339.7   Max.   :2775   Max.   :2522.8
       T                RH               AH
 Min.   :-1.90   Min.   : 9.175   Min.   :0.1847
 1st Qu.:12.03   1st Qu.:36.550   1st Qu.:0.7461
 Median :18.27   Median :49.232   Median :1.0154
 Mean   :18.32   Mean   :49.232   Mean   :1.0255
 3rd Qu.:24.07   3rd Qu.:61.875   3rd Qu.:1.2962
 Max.   :44.60   Max.   :88.725   Max.   :2.2310
```

Conclusion/Interpretation:

Missing values are hence imputed

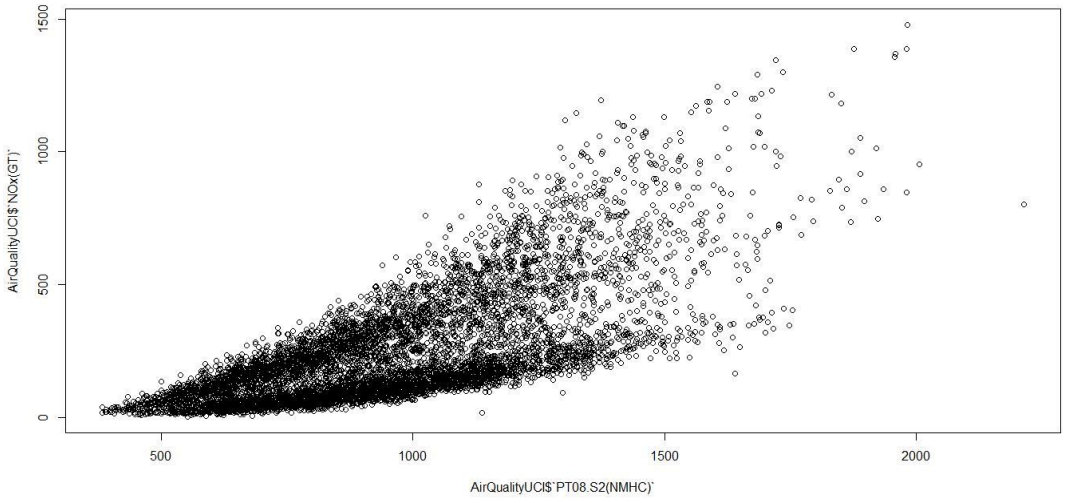
e) Create bi-variate analysis for all relationships

The R-script for the given problem is as follows:

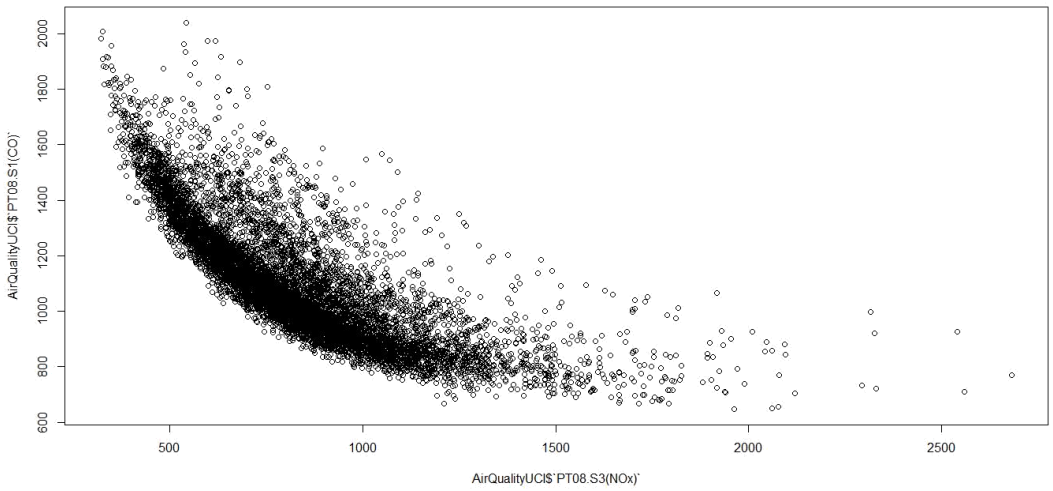
```
summary(AirQualityUCI)
plot(AirQualityUCI$`NOx(GT)`~AirQualityUCI$`PT08.S2(NMHC)`)
plot(AirQualityUCI$`PT08.S1(CO)`~AirQualityUCI$`PT08.S3(NOx)`)
plot(AirQualityUCI$`NO2(GT)`~AirQualityUCI$`PT08.S4(NO2)`)
plot(AirQualityUCI$`PT08.S5(O3)`~AirQualityUCI$T)
#or
pairs(AirQualityUCI)    # graph

final <- complete
final$Date <- AirQualityUCI$Date
final$Time <- AirQualityUCI$Time
library(stringr)
AirQualityUCI$Time1 <- sub(".+? ", "", AirQualityUCI$Time)
AirQualityUCI$datetime <- as.POSIXct(paste(AirQualityUCI$Date,
AirQualityUCI$Time1), format="%Y-%m-%d %H:%M:%S")
View(AirQualityUCI)
str(AirQualityUCI)
```

The output of the R-Script (from Console window) is given as follows:

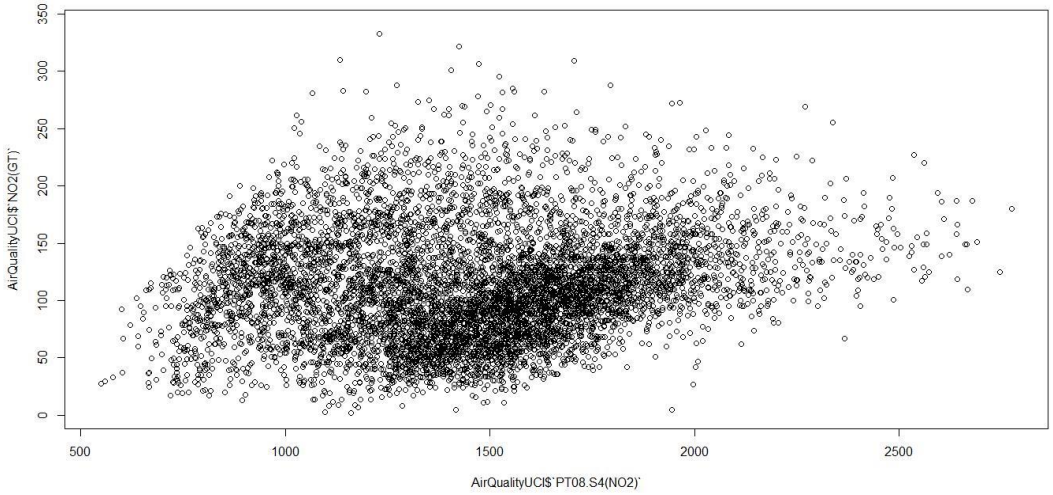
```
> plot(AirQualityUCI$`NOx(GT)`~AirQualityUCI$`PT08.S2(NMHC)`)
```



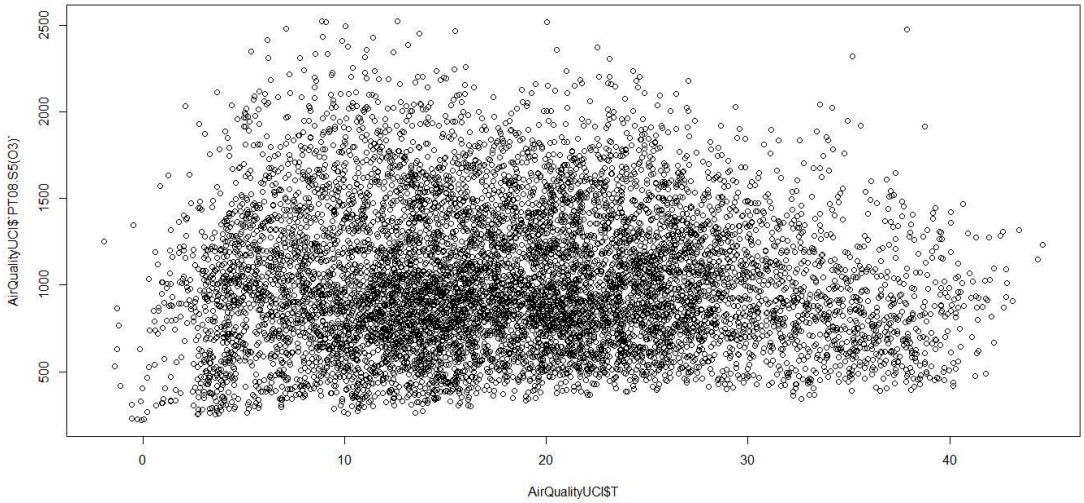

```
> plot(AirQualityUCI$`PT08.S1(CO)`~AirQualityUCI$`PT08.S3(NOx)`)
```



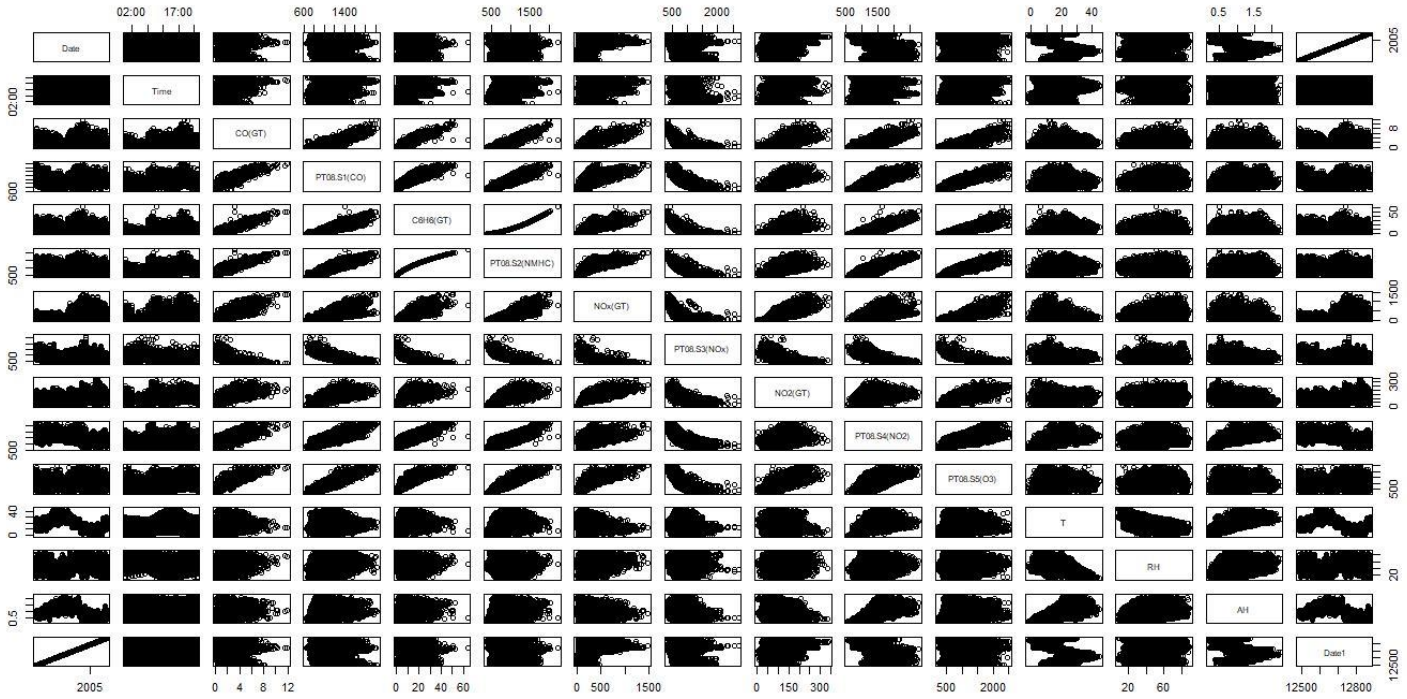

```
> plot(AirQualityUCI$`NO2(GT)`~AirQualityUCI$`PT08.S4(NO2)`)
```




```
> plot(AirQualityUCI$`PT08.S5(O3)`~AirQualityUCI$T)
```



```
> pairs(AirQualityUCI)    # graph
```




```
> final <- complete
> final$Date <- AirQualityUCI$Date
> final$Time <- AirQualityUCI$Time
> library(stringr)
> AirQualityUCI$Time1 <- sub(".+? ", "", AirQualityUCI$Time)
> AirQualityUCI$datetime <- as.POSIXct(paste(AirQualityUCI$Date,
AirQualityUCI$Time1), format="%Y-%m-%d %H:%M:%S")
> View(AirQualityUCI)
> str(AirQualityUCI)
                  'tbl
Classes 'tbl_df', 'and      'data.frame':     9357 obs. of  17 variables:
 $ Date          : POSIXct, format: "2004-03-10" "2004-03-10" "2004-03-10" ...
 $ Time          : POSIXct, format: "1899-12-31 18:00:00" "1899-12-31
19:00:00" "1899-12-31 20:00:00" ...
 $ CO(GT)        : num  2.6 2  2.2 2.2 1.6 1.2 1.2 1 0.9 0.6 ...
 $ PT08.S1(CO)   : num        1292 1402 1376 1272 ...
 $ C6H6(GT)      : num  11.88  9.4 9 9.23 6.52 ...
 $ PT08.S2(NMHC): num       955 939 948 836 ...
 $ NOx(GT)       : num  166 103 131 172 131 89 62 62 45 NA ...
 $ PT08.S3(NOx)  : num        1174 1140 1092 1205 ...
 $ NO2(GT)       : num  113 92 114 122 116 96 77 76 60 NA ...
 $ PT08.S4(NO2)  : num        1559 1554 1584 1490 ...
 $ PT08.S5(O3)   : num       972 1074 1203 1110 ...
 $ T             : num        13.3 11.9 11 11.2 ...
 $ RH            : num        47.7 54 60 59.6 ...
 $ AH            : num  0.758 0.725 0.75 0.787 0.789 ...
 $ Date1         : num  12487 12487 12487 12487 12487 ...
 $ Time1         : chr  "18:00:00" "19:00:00" "20:00:00" "21:00:00" ...
 $ datetime      : POSIXct, format: "2004-03-10 18:00:00" "2004-03-10
19:00:00" "2004-03-10 20:00:00" ...
```

Conclusion/Interpretation:

Bi-variate analysis for all relationships are done and plotted.

f) Test relevant hypothesis for valid relations

The R-script for the given problem is as follows:

```
t.test(AirQualityUCI$`CO(GT)`, AirQualityUCI$`PT08.S1(CO)`, paired = T)
t.test(AirQualityUCI$`C6H6(GT)`, AirQualityUCI$`PT08.S2(NMHC)`, paired = T)
t.test(AirQualityUCI$`NOx(GT)`, AirQualityUCI$`PT08.S3(NOx)`, paired = T)

mod <- lm(AirQualityUCI$`CO(GT)`~AirQualityUCI$Date1)
summary(mod)

mod <- lm(AirQualityUCI$`CO(GT)`~AirQualityUCI$T)
summary(mod)

mod <- lm(AirQualityUCI$`CO(GT)`~AirQualityUCI$RH)
summary(mod)
```

The output of the R-Script (from Console window) is given as follows:

```
> t.test(AirQualityUCI$`CO(GT)`, AirQualityUCI$`PT08.S1(CO)`, paired = T)

        Paired t-test

data: AirQualityUCI$`CO(GT)` and AirQualityUCI$`PT08.S1(CO)`
t = -436.85, df = 7343, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1113.299 -1103.352
sample estimates:
mean of the differences
              -1108.325

> t.test(AirQualityUCI$`C6H6(GT)`, AirQualityUCI$`PT08.S2(NMHC)`, paired =

        T) Paired t-test

data: AirQualityUCI$`C6H6(GT)` and AirQualityUCI$`PT08.S2(NMHC)`
t = -339.41, df = 8990, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -934.3112 -923.5812
sample estimates:
mean of the differences
              -928.9462

> t.test(AirQualityUCI$`NOx(GT)`, AirQualityUCI$`PT08.S3(NOx)`, paired =

        T) Paired t-test

data: AirQualityUCI$`NOx(GT)` and AirQualityUCI$`PT08.S3(NOx)`
t = -118.66, df = 7395, p-value < 2.2e-16
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
```

```
 -591.8554 -572.6187
sample estimates:
mean of the differences
              -582.2371

> mod <- lm(AirQualityUCI$`CO(GT)`~AirQualityUCI$Date1)
> summary(mod)

Call:
lm(formula = AirQualityUCI$`CO(GT)` ~ AirQualityUCI$Date1)

Residuals:
    Min 1Q Median 3Q Max -2.1512 -
1.0913 -0.3337 0.7422 9.7166

Coefficients:
                      Estimate Std. Error t value Pr(>|t|)
(Intercept) -4.8415230 1.8033975 -2.685 0.007276 **
AirQualityUCI$Date1 0.0005512 0.0001421 3.879 0.000106 *** ---

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.452 on 7672 degrees of
  freedom (1683 observations deleted due to missingness)
Multiple R-squared:  0.001957, Adjusted R-squared:  0.001827
F-statistic: 15.04 on 1 and 7672 DF,  p-value: 0.000106

>
> mod <- lm(AirQualityUCI$`CO(GT)`~AirQualityUCI$T)
> summary(mod)

Call:
lm(formula = AirQualityUCI$`CO(GT)` ~ AirQualityUCI$T)

Residuals:
    Min 1Q Median 3Q Max -2.1099 -
1.0686 -0.3368 0.7071 9.7894

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     2.066033   0.037547  55.025   <2e-16 ***
AirQualityUCI$T 0.003584   0.001891   1.895   0.0581 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.436 on 7342 degrees of
  freedom (2013 observations deleted due to missingness)
Multiple R-squared:  0.000489, Adjusted R-squared:  0.0003528
F-statistic: 3.592 on 1 and 7342 DF,  p-value: 0.0581

>
> mod <- lm(AirQualityUCI$`CO(GT)`~AirQualityUCI$RH)
> summary(mod)

Call:
lm(formula = AirQualityUCI$`CO(GT)` ~ AirQualityUCI$RH)

Residuals:
    Min 1Q Median 3Q Max -2.1595 -
1.0712 -0.3169 0.7328 9.6671
```

```
Coefficients:
                  Estimate Std. Error t value  Pr(>|t|)
(Intercept)       1.9322601  0.0499611  38.675  < 2e-16 ***
AirQualityUCI$RH 0.0040248   0.0009595   4.195 2.76e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.435 on 7342 degrees of
  freedom (2013 observations deleted due to missingness)
Multiple R-squared:  0.002391, Adjusted R-squared: 0.002255
F-statistic:  17.6 on 1 and 7342 DF,  p-value: 2.765e-05
```

g) Create cross tabulations with derived variables

The R-script for the given problem is as follows:

```
mydata<-AirQualityUCI
View(mydata) # 2-Way Frequency Table
attach(mydata)
#mytable <- table(A,B) # A will be rows, B will be
columns #mytable # print table
margin.table(mytable, 1) # A frequencies (summed over B)
prop.table(mytable) # cell percentages prop.table(mytable,
1) # row percentages


range(AirQualityUCI$RH)

final <- within(AirQualityUCI,
            {
              RHcat <- NA
              RHcat[RH<20] <- "Very Low"
              RHcat[RH>=20 & RH<=40] <- "Low"
              RHcat[RH>40 & RH<=60] <- "Medium"
              RHcat[RH>60 & RH<=80] <- "High"
              RHcat[RH>80] <- "Very High"
            })

mytable <- xtabs(`CO(GT)` ~ +RHcat, data = final)
ftable(mytable) # print table
summary(mytable) # chi-square test of indepedence

mytable <- xtabs(`C6H6(GT)` ~ +RHcat, data = final)
ftable(mytable) # print table
summary(mytable) # chi-square test of indepedence

mytable <- xtabs(`NOx(GT)` ~ +RHcat, data = final)
```

```
ftable(mytable) # print table
summary(mytable) # chi-square test of indepedence

with(final, tapply(`NO2(GT)`, list(RHcat=RHcat), sd)) # using with()
with(final, tapply(`NO2(GT)`, list(RHcat=RHcat), mean))
```

The output of the R-Script (from Console window) is given as follows:

```
> mydata<-AirQualityUCI
> View(mydata) # 2-Way Frequency Table
> attach(mydata)
The following objects are masked from mydata (pos = 5):

    AH, C6H6(GT), CO(GT), Date, datetime, NO2(GT), NOx(GT), PT08.S1(CO),
    PT08.S2(NMHC), PT08.S3(NOx), PT08.S4(NO2), PT08.S5(O3), RH, T, Time, Time1

The following objects are masked from mydata (pos = 6):

    AH, C6H6(GT), CO(GT), Date, datetime, NO2(GT), NOx(GT), PT08.S1(CO),
    PT08.S2(NMHC), PT08.S3(NOx), PT08.S4(NO2), PT08.S5(O3), RH, T, Time, Time1

The following object is masked from package:base:

    T

> #mytable <- table(A,B) # A will be rows, B will be columns
> #mytable # print table
> margin.table(mytable, 1) # A frequencies (summed over
B) RHcat
     High       Low    Medium Very High  Very Low
 566943.9  417357.3  664434.1   77071.7   65314.5
> prop.table(mytable) # cell percentages
RHcat
      High  Low  Medium  Very  High  Very  Low  0.31653012
0.23301451 0.37095981 0.04302986 0.03646570
> prop.table(mytable, 1) # row
percentages RHcat
     High       Low    Medium Very High  Very Low
        1         1         1         1         1
>
>
> range(AirQualityUCI$RH)
[1] NA NA
>
> final <- within(AirQualityUCI,
+                 {
+                   RHcat <- NA
+                   RHcat[RH<20] <- "Very Low"
+                   RHcat[RH>=20 & RH<=40] <- "Low"
+                   RHcat[RH>40 & RH<=60] <- "Medium"
+                   RHcat[RH>60 & RH<=80] <- "High"
+                   RHcat[RH>80] <- "Very High"
+                 })
>
> mytable <- xtabs(`CO(GT)` ~ +RHcat, data = final)
> ftable(mytable)  # print table
mytable 497.1 662.5 4288.7 4302.4 5889.9

            1     1      1      1      1
> summary(mytable) # chi-square test of
indepedence Number of cases in table: 15640.6
Number of factors: 1
>
> mytable <- xtabs(`C6H6(GT)` ~  +RHcat, data = final)
> ftable(mytable)  # print table
mytable 2206.4370307221 4537.99826996217 23277.0380810769 25828.1012760302
```

```
34806.619496821

                      1               1               1               1
1
> summary(mytable) # chi-square test of
indepedence Number of cases in table: 90656.19
Number of factors: 1
>
> mytable <- xtabs(`NOx(GT)` ~  +RHcat, data = final)
> ftable(mytable)  # print table
mytable 65314.5 77071.7 417357.3 566943.9 664434.1

              1       1       1       1       1
> summary(mytable) # chi-square test of
indepedence Number of cases in table: 1791122
Number of factors: 1
>
> with(final, tapply(`NO2(GT)`, list(RHcat=RHcat), sd)) # using with()
RHcat

       High        Low     Medium Very High  Very Low
         NA         NA         NA         NA         NA
> with(final, tapply(`NO2(GT)`, list(RHcat=RHcat),
mean)) RHcat
     High        Low     Medium Very High  Very Low
       NA         NA         NA         NA         NA
```

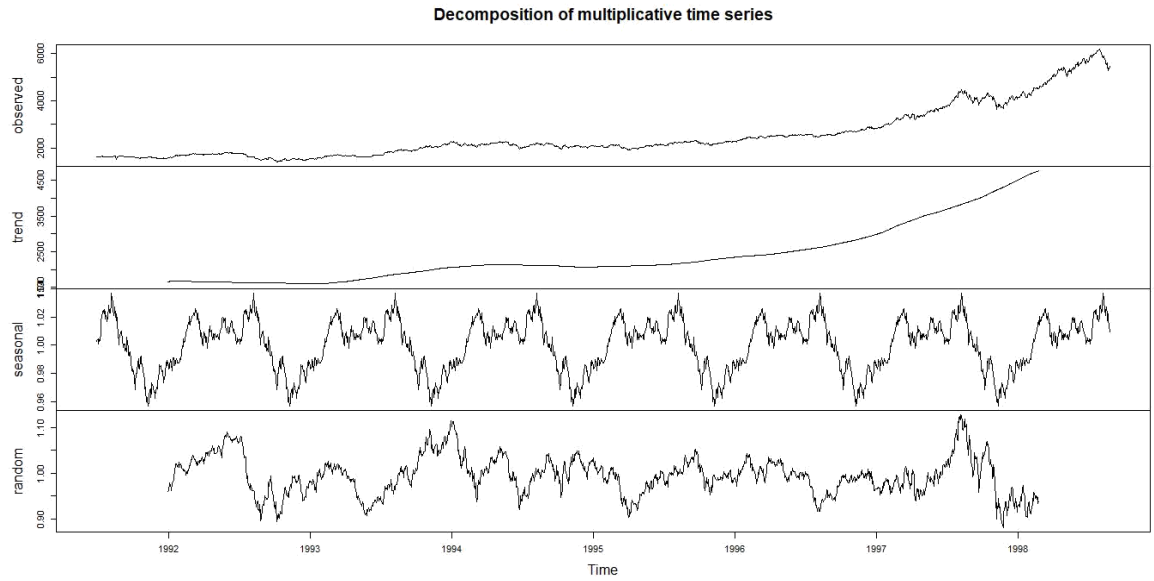
h) Check for trends and patterns in time series

The R-script for the given problem is as follows:

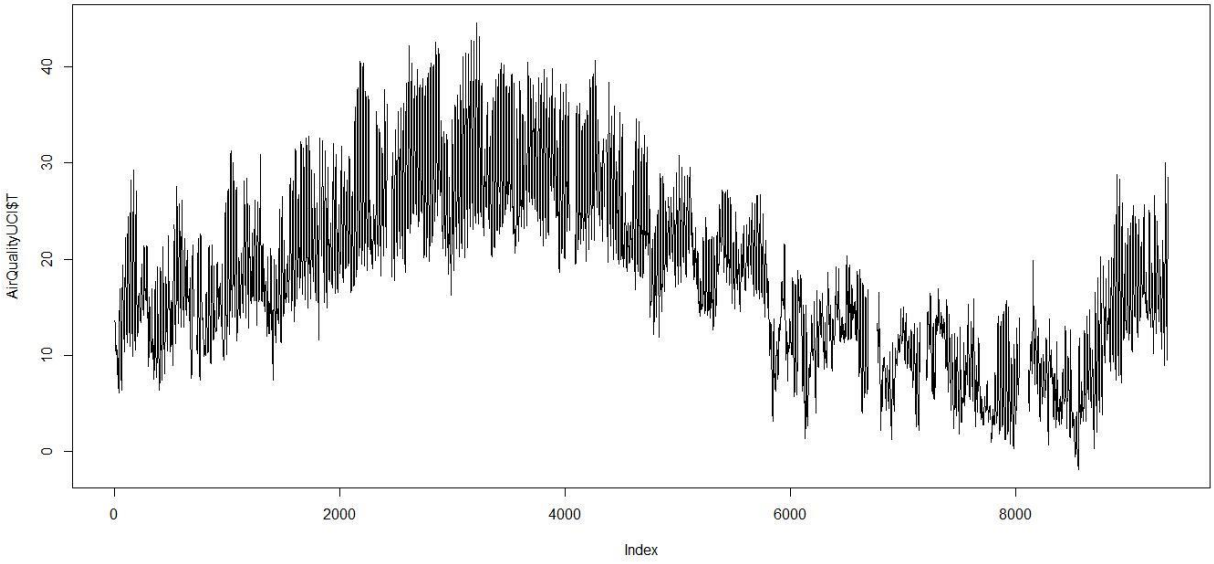
```
#plot time series
tsAirqualityUCI <- EuStockMarkets[, 1] # ts data
decomposedRes <- decompose(tsAirqualityUCI, type="mult") # use type = "additive" for
additive components
plot (decomposedRes) # see plot below
stlRes <- stl(tsAirqualityUCI, s.window = "periodic")
plot(AirQualityUCI$T, type = "l")

#or
library(xts)
timeseries <- xts(final$`CO(GT)`, final$datetime)
plot(timeseries)
summary(timeseries)
ts (AirQualityUCI, frequency = 4, start = c(1959, 2))# frequency 4 =>Quarterly
Data ts (1:10, frequency = 12, start = 1990) # freq 12 => Monthly data.
ts (AirQualityUCI, start=c(2009), end=c(2014), frequency=1) # Yearly Data
ts (1:1000, frequency = 365, start = 1990) # freq 365 => daily data.
```

The output of the R-Script (from Console window) is given as follows:

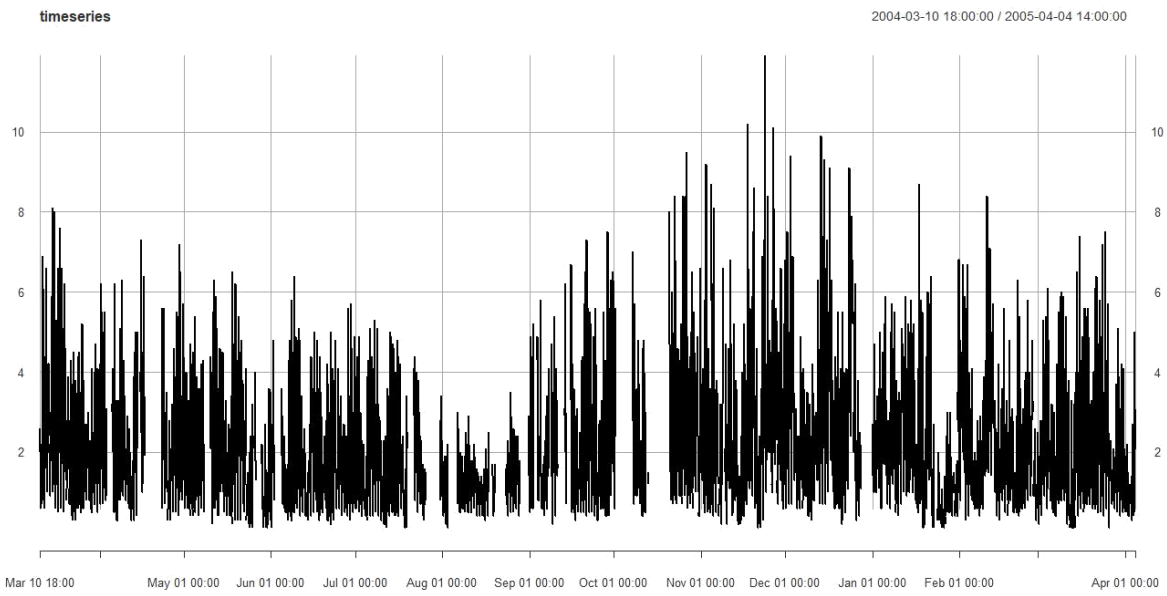
```
> #plot time series
> tsAirqualityUCI <- EuStockMarkets[, 1] # ts data
> decomposedRes <- decompose(tsAirqualityUCI, type="mult") # use type =
"additive" for additive components
> plot (decomposedRes) # see plot below
```




```
> stlRes <- stl(tsAirqualityUCI, s.window = "periodic")
> plot(AirQualityUCI$T, type = "l")
```




```
> library(xts)
>
> timeseries <- xts(final$`CO(GT)`, final$datetime)
> plot(timeseries)
> summary(timeseries)
      Index                       timeseries
 Min.    :2004-03-10 18:00:00   Min.   : 0.100
  1st Qu.:2004-06-16 05:00:00   1st Qu.: 1.100
 Median :2004-09-21 16:00:00   Median : 1.800
 Mean    :2004-09-21 16:00:00   Mean   : 2.153
  3rd Qu.:2004-12-28 03:00:00   3rd Qu.: 2.900
 Max.    :2005-04-04 14:00:00   Max.   :11.900
                                NA's   :1683
```




```
> ts (AirQualityUCI, frequency = 4, start = c(1959, 2))# frequency
4 =>Quarterly Data
             Date        Time CO(GT) PT08.S1(CO)   C6H6(GT) PT08.S2(NMHC)
 NOx(GT)
1959  Q2 1078876800  -2209010400    2.6   1360.0000 11.8817235     1045.5000
166.0
1959  Q3 1078876800  -2209006800    2.0   1292.2500  9.3971649      954.7500
103.0
1959  Q4 1078876800  -2209003200    2.2   1402.0000  8.9978169      939.2500
131.0
1960  Q1 1078876800  -2208999600    2.2   1375.5000  9.2287964      948.2500
172.0
1960  Q2 1078876800  -2208996000    1.6   1272.2500  6.5182237      835.5000
131.0
1960  Q3 1078876800  -2208992400    1.2   1197.0000  4.7410124      750.2500
89.0
1960  Q4 1078963200  -2209075200    1.2   1185.0000  3.6243992      689.5000
62.0
1961  Q1 1078963200  -2209071600    1.0   1136.2500  3.3266770      672.0000
62.0
1961  Q2 1078963200  -2209068000    0.9   1094.0000  2.3394162      608.5000
45.0
1961  Q3 1078963200  -2209064400    0.6   1009.7500  1.6966583      560.7500
NA
1961  Q4 1078963200  -2209060800     NA   1011.0000  1.2936198      526.7500
21.0
1962  Q1 1078963200  -2209057200    0.7   1066.0000  1.1334306      512.0000
16.0
1962  Q2 1078963200  -2209053600    0.7   1051.7500  1.6037679      553.2500
34.0
1962  Q3 1078963200  -2209050000    1.1   1144.0000  3.2436181      667.0000
98.0
1962  Q4 1078963200  -2209046400    2.0   1333.2500  8.0137730      899.7500
174.0
```

1963 Q1 1078963200 -2209042800 2.2 1351.0000 9.5406429 960.2500
129.0
1963 Q2 1078963200 -2209039200 1.7 1233.2500 6.3357824 827.2500
112.0
1963 Q3 1078963200 -2209035600 1.5 1178.7500 4.9715838 762.0000
95.0
1963 Q4 1078963200 -2209032000 1.6 1236.0000 5.2169190 774.2500
104.0
1964 Q1 1078963200 -2209028400 1.9 1285.5000 7.2699334 868.5000
146.0
1964 Q2 1078963200 -2209024800 2.9 1371.0000 11.5390072 1033.5000
207.0
1964 Q3 1078963200 -2209021200 2.2 1310.0000 8.8262227 932.5000
184.0
1964 Q4 1078963200 -2209017600 2.2 1291.7500 8.3014134 911.5000
193.0
1965 Q1 1078963200 -2209014000 2.9 1383.0000 11.1515812 1019.7500
243.0
1965 Q2 1078963200 -2209010400 4.8 1580.7500 20.7992169 1318.5000
281.0
1965 Q3 1078963200 -2209006800 6.9 1775.5000 27.3598075 1487.7500
383.0
1965 Q4 1078963200 -2209003200 6.1 1640.0000 24.0177569 1404.0000
351.0
1966 Q1 1078963200 -2208999600 3.9 1312.7500 12.7793682 1076.2500
240.0
1966 Q2 1078963200 -2208996000 1.5 964.5000 4.7070719 748.5000
94.0
1966 Q3 1078963200 -2208992400 1.0 912.7500 2.6457215 629.2500
47.0
1966 Q4 1079049600 -2209075200 1.7 1080.2500 5.8548015 805.0000
122.0
1967 Q1 1079049600 -2209071600 1.9 1043.7500 6.3742975 829.0000
133.0
1967 Q2 1079049600 -2209068000 1.4 987.7500 4.1323418 718.0000
82.0
1967 Q3 1079049600 -2209064400 0.8 888.7500 1.8694446 574.2500
NA
1967 Q4 1079049600 -2209060800 NA 831.0000 1.0682926 505.7500
21.0
1968 Q1 1079049600 -2209057200 0.6 847.2500 1.0224146 501.2500
30.0
1968 Q2 1079049600 -2209053600 0.8 927.0000 1.8304312 571.2500
56.0
1968 Q3 1079049600 -2209050000 1.4 1090.5000 4.3593410 730.2500
109.0
1968 Q4 1079049600 -2209046400 4.4 1587.0000 17.8655867 1235.5000
307.0
1969 Q1 1079049600 -2209042800 NA 1544.5000 22.0741621 1353.0000
NA
1969 Q2 1079049600 -2209039200 3.1 1350.2500 14.0270114 1117.5000
187.0
1969 Q3 1079049600 -2209035600 2.7 1262.7500 11.6456466 1037.2500
216.0
1969 Q4 1079049600 -2209032000 2.1 1206.2500 10.2246621 986.0000
143.0

```
1970 Q1 1079049600 -2209028400     2.5   1251.5000 11.0399360     1015.7500
160.0
1970 Q2 1079049600 -2209024800     2.7   1287.0000 12.8164462     1077.5000
163.0
1970 Q3 1079049600 -2209021200     2.9   1352.7500 14.1738512     1122.2500
190.0
1970 Q4 1079049600 -2209017600     2.8   1309.0000 12.6905681     1073.2500
178.0
1971 Q1 1079049600 -2209014000     2.4   1274.0000 11.7384054     1040.5000
150.0
1971 Q2 1079049600 -2209010400     3.9   1509.5000 19.2909749     1276.5000
206.0
1971 Q3 1079049600 -2209006800     3.7   1525.2500 18.2261783     1246.0000
202.0
1971 Q4 1079049600 -2209003200     6.6   1843.0000 32.5562783     1609.7500
340.0
1972 Q1 1079049600 -2208999600     4.4   1597.7500 20.0929436     1299.0000
274.0
1972 Q2 1079049600 -2208996000     3.5   1483.5000 14.3213424     1127.0000
253.0
1972 Q3 1079049600 -2208992400     5.4   1677.2500 21.8128651     1346.0000
300.0
1972 Q4 1079136000 -2209075200     2.7   1279.5000  9.6389998      964.0000
193.0
1973 Q1 1079136000 -2209071600     1.9   1196.2500  7.3751395      873.0000
139.0
1973 Q2 1079136000 -2209068000     1.6   1183.7500  5.3696042      781.7500
83.0
1973 Q3 1079136000 -2209064400     1.7   1171.7500  5.3901039      782.7500
NA
        PT08.S3(NOx) NO2(GT) PT08.S4(NO2) PT08.S5(O3)          T        RH
AH Date1 Time1
1959 Q2    1056.2500    113.0    1692.0000   1267.5000 13.600000 48.87500
0.7577538 12487    NA
1959 Q3    1173.7500     92.0    1558.7500    972.2500 13.300000 47.70000
0.7254874 12487    NA
1959 Q4    1140.0000    114.0    1554.5000   1074.0000 11.900000 53.97500
0.7502391 12487    NA
1960 Q1    1092.0000    122.0    1583.7500   1203.2500 11.000000 60.00000
0.7867125 12487    NA
1960 Q2    1205.0000    116.0    1490.0000   1110.0000 11.150000 59.57500
0.7887942 12487    NA
1960 Q3    1336.5000     96.0    1393.0000    949.2500 11.175000 59.17500
0.7847717 12487    NA
1960 Q4    1461.7500     77.0    1332.7500    732.5000 11.325000 56.77500
0.7603119 12488    NA
1961 Q1    1453.2500     76.0    1332.7500    729.5000 10.675000 60.00000
0.7702385 12488    NA
1961 Q2    1579.0000     60.0    1276.0000    619.5000 10.650000 59.67500
0.7648187 12488    NA
1961 Q3    1705.0000       NA    1234.7500    501.2500 10.250000 60.20000
0.7516572 12488    NA
1961 Q4    1817.5000     34.0    1196.7500    445.2500 10.075000 60.47500
0.7464945 12488    NA
1962 Q1    1918.0000     28.0    1182.0000    421.7500 11.000000 56.17500
0.7365596 12488    NA
```

```
1962 Q2     1738.2500    48.0    1221.2500    471.5000 10.450000 58.12500
0.7352951 12488     NA
1962 Q3     1489.7500    82.0    1339.0000    729.7500 10.200000 59.60000
0.7417362 12488     NA
1962 Q4     1136.0000   112.0    1517.0000   1101.5000 10.750000 57.42500
0.7407946 12488     NA
1963 Q1     1079.0000   101.0    1582.7500   1027.7500 10.500000 60.60000
0.7691108 12488     NA
1963 Q2     1218.0000    98.0    1445.7500    859.7500 10.800000 58.35000
0.7551831 12488     NA
1963 Q3     1327.5000    92.0    1361.7500    670.5000 10.500000 57.92500
0.7351608 12488     NA
1963 Q4     1301.2500    95.0    1401.2500    664.0000  9.525000 66.77500
0.7950538 12488     NA
1964 Q1     1162.2500   112.0    1536.7500    799.0000  8.300000 76.42500
0.8392681 12488     NA
1964 Q2      983.2500   128.0    1730.2500   1036.5000  8.000000 81.15000
0.8735885 12488     NA
1964 Q3     1081.7500   126.0    1646.5000    946.2500  8.325000 79.80000
0.8777844 12488     NA
1964 Q4     1102.5000   131.0    1590.7500    956.7500  9.700000 71.15000
0.8569381 12488     NA
1965 Q1     1008.0000   135.0    1718.7500   1104.0000  9.775000 67.62500
0.8185012 12488     NA
1965 Q2      798.5000   151.0    2083.0000   1408.5000 10.350000 64.17500
0.8065436 12488     NA
1965 Q3      702.2500   172.0    2332.5000   1704.0000  9.650000 69.30000
0.8319211 12488     NA
1965 Q4      742.7500   165.0    2191.2500   1653.7500  9.650000 67.75000
0.8133139 12488     NA
1966 Q1      957.2500   136.0    1706.5000   1284.7500  9.125000 63.97500
0.7419242 12488     NA
1966 Q2     1325.2500    85.0    1332.5000    821.0000  8.175000 63.40000
0.6904844 12488     NA
1966 Q3     1564.5000    53.0    1252.2500    551.7500  8.250000 60.82500
0.6657444 12488     NA
1966 Q4     1253.5000    97.0    1375.0000    815.5000  8.325000 58.52500
0.6437636 12489     NA
1967 Q1     1247.2500   110.0    1378.2500    831.5000  7.725000 59.67500
0.6307661 12489     NA
1967 Q2     1395.5000    91.0    1303.5000    691.5000  7.125000 61.80000
0.6275974 12489     NA
1967 Q3     1680.2500      NA    1187.0000    512.0000  6.975000 62.27500
0.6261075 12489     NA
1967 Q4     1892.7500    32.0    1133.7500    384.0000  6.100000 65.90000
0.6247536 12489     NA
1968 Q1     1894.5000    44.0    1154.7500    394.0000  6.275000 64.97500
0.6232823 12489     NA
1968 Q2     1684.7500    71.0    1222.7500    486.5000  6.750000 62.95000
0.6234275 12489     NA
1968 Q3     1387.0000   104.0    1360.7500    748.2500  6.450000 65.07500
0.6316281 12489     NA
1968 Q4      896.5000   141.0    1900.2500   1400.2500  7.325000 63.15000
0.6499331 12489     NA
1969 Q1      767.2500      NA    2058.0000   1587.7500  9.225000 56.20000
0.6560651 12489     NA
```

```
1969 Q2      912.0000   122.0    1711.7500   1237.0000 13.225000 41.75000
0.6319501 12489     NA
1969 Q3      969.0000   143.0    1598.2500   1166.5000 14.325000 38.45000
0.6243043 12489     NA
1969 Q4     1034.5000   113.0    1537.0000    959.0000 15.025000 36.50000
0.6195323 12489     NA
1970 Q1     1007.5000   116.0    1592.7500    983.0000 16.100000 34.47500
0.6261647 12489     NA
1970 Q2      948.7500   123.0    1660.2500   1060.7500 16.275001 35.72500
0.6560306 12489     NA
1970 Q3      921.7500   126.0    1740.0000   1139.2500 15.825000 37.02500
0.6609611 12489     NA
1970 Q4      954.0000   120.0    1657.2500   1112.2500 15.875000 37.17500
0.6657285 12489     NA
1971 Q1     1005.7500   119.0    1609.7500    993.7500 16.875000 34.35000
0.6549085 12489     NA
1971 Q2      812.2500   149.0    1909.7500   1409.5000 15.150000 39.55000
0.6766265 12489     NA
1971 Q3      821.0000   145.0    1846.7500   1447.7500 14.400000 43.42500
0.7084498 12489     NA
1971 Q4      624.0000   170.0    2390.2500   1886.5000 12.875000 50.52500
0.7478032 12489     NA
1972 Q1      752.0000   149.0    1940.5000   1626.7500 12.150000 53.35000
0.7536202 12489     NA
1972 Q2      839.0000   139.0    1723.0000   1491.0000 10.975000 59.12500
0.7739800 12489     NA
1972 Q3      740.5000   134.0    2062.0000   1657.0000  9.675000 64.62500
0.7770739 12489     NA
1972 Q4      962.5000   113.0    1543.5000   1285.2500  9.450000 64.12500
0.7597465 12490     NA
1973 Q1     1071.2500    97.0    1463.2500   1144.2500  9.150000 63.90000
0.7422764 12490     NA
1973 Q2     1176.2500    82.0    1364.5000   1042.7500  8.800000 63.92500
0.7256154 12490     NA
1973 Q3     1178.5000      NA    1379.7500    995.5000  7.800000 67.52500
0.7173121 12490     NA
          datetime
1959 Q2 1078921800
1959 Q3 1078925400
1959 Q4 1078929000
1960 Q1 1078932600
1960 Q2 1078936200
1960 Q3 1078939800
1960 Q4 1078943400
1961 Q1 1078947000
1961 Q2 1078950600
1961 Q3 1078954200
1961 Q4 1078957800
1962 Q1 1078961400
1962 Q2 1078965000
1962 Q3 1078968600
1962 Q4 1078972200
1963 Q1 1078975800
1963 Q2 1078979400
1963 Q3 1078983000
1963 Q4 1078986600
1964 Q1 1078990200
```

```
1964 Q2 1078993800
1964 Q3 1078997400
1964 Q4 1079001000
1965 Q1 1079004600
1965 Q2 1079008200
1965 Q3 1079011800
1965 Q4 1079015400
1966 Q1 1079019000
1966 Q2 1079022600
1966 Q3 1079026200
1966 Q4 1079029800
1967 Q1 1079033400
1967 Q2 1079037000
1967 Q3 1079040600
1967 Q4 1079044200
1968 Q1 1079047800
1968 Q2 1079051400
1968 Q3 1079055000
1968 Q4 1079058600
1969 Q1 1079062200
1969 Q2 1079065800
1969 Q3 1079069400
1969 Q4 1079073000
1970 Q1 1079076600
1970 Q2 1079080200
1970 Q3 1079083800
1970 Q4 1079087400
1971 Q1 1079091000
1971 Q2 1079094600
1971 Q3 1079098200
1971 Q4 1079101800
1972 Q1 1079105400
1972 Q2 1079109000
1972 Q3 1079112600
1972 Q4 1079116200
1973 Q1 1079119800
1973 Q2 1079123400
1973 Q3 1079127000
 [ reached getOption("max.print") -- omitted 9299 rows ]
> ts (1:10, frequency = 12, start = 1990) # freq 12 => Monthly
     data. Jan Feb Mar Apr May Jun Jul Aug Sep Oct
1990   1   2   3   4   5   6   7   8   9  10
> ts (AirQualityUCI, start=c(2009), end=c(2014), frequency=1) # Yearly Data
Time Series:
Start = 2009
End = 2014
Frequency = 1
           Date        Time CO(GT) PT08.S1(CO)  C6H6(GT) PT08.S2(NMHC)
NOx(GT) PT08.S3(NOx)
2009 1078876800  -2209010400    2.6     1360.00 11.881723      1045.50
166      1056.25
2010 1078876800  -2209006800    2.0     1292.25  9.397165       954.75
103      1173.75
2011 1078876800  -2209003200    2.2     1402.00  8.997817       939.25
131      1140.00
2012 1078876800  -2208999600    2.2     1375.50  9.228796       948.25
172      1092.00
```

```
2013  1078876800 -2208996000    1.6     1272.25  6.518224        835.50
131       1205.00
2014  1078876800 -2208992400    1.2     1197.00  4.741012        750.25
89       1336.50
      NO2(GT) PT08.S4(NO2) PT08.S5(O3)      T     RH        AH Date1 Time1
datetime
2009      113      1692.00     1267.50 13.600 48.875 0.7577538  12487    NA
1078921800
2010       92      1558.75      972.25 13.300 47.700 0.7254874  12487    NA
1078925400
2011      114      1554.50     1074.00 11.900 53.975 0.7502391  12487    NA
1078929000
2012      122      1583.75     1203.25 11.000 60.000 0.7867125  12487    NA
1078932600
2013      116      1490.00     1110.00 11.150 59.575 0.7887942  12487    NA
1078936200
2014       96      1393.00      949.25 11.175 59.175 0.7847717  12487    NA
1078939800
> ts (1:1000, frequency = 365, start = 1990) # freq 365 => daily data.
Time Series:
Start = c(1990, 1)
End = c(1992, 270)
Frequency = 365
    [1]   1     2     3     4     5     6     7     8     9   10   11   12   13  14
15   16   17
   [18]   18   19   20   21   22   23   24   25   26   27   28   29   30  31
32   33   34
   [35]   35   36   37   38   39   40   41   42   43   44   45   46   47  48
49   50   51
   [52]   52   53   54   55   56   57   58   59   60   61   62   63   64  65
66   67   68
   [69]   69   70   71   72   73   74   75   76   77   78   79   80   81  82
83   84   85
   [86]   86   87   88   89   90   91   92   93   94   95   96   97   98  99
100  101  102
  [103]  103  104  105  106  107  108  109  110  111  112  113  114  115 116
117  118  119
  [120]  120  121  122  123  124  125  126  127  128  129  130  131  132 133
134  135  136
  [137]  137  138  139  140  141  142  143  144  145  146  147  148  149 150
151  152  153
  [154]  154  155  156  157  158  159  160  161  162  163  164  165  166 167
168  169  170
  [171]  171  172  173  174  175  176  177  178  179  180  181  182  183 184
185  186  187
  [188]  188  189  190  191  192  193  194  195  196  197  198  199  200 201
202  203  204
  [205]  205  206  207  208  209  210  211  212  213  214  215  216  217 218
219  220  221
  [222]  222  223  224  225  226  227  228  229  230  231  232  233  234 235
236  237  238
  [239]  239  240  241  242  243  244  245  246  247  248  249  250  251 252
253  254  255
  [256]  256  257  258  259  260  261  262  263  264  265  266  267  268 269
270  271  272
  [273]  273  274  275  276  277  278  279  280  281  282  283  284  285 286
287  288  289
```

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304 305 306
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576 577 578
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593 594 595
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610 611 612
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627 628 629
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644 645 646
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661 662 663
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678 679 680
[681] 681 682 683 684 685 686 687 688 689 690 691 692 693 694
695 696 697
[698] 698 699 700 701 702 703 704 705 706 707 708 709 710 711
712 713 714
[715] 715 716 717 718 719 720 721 722 723 724 725 726 727 728
729 730 731
[732] 732 733 734 735 736 737 738 739 740 741 742 743 744 745
746 747 748
[749] 749 750 751 752 753 754 755 756 757 758 759 760 761 762
763 764 765

```
 [766]  766  767  768  769  770  771  772  773  774  775  776  777  778 779
780 781  782
 [783]  783  784  785  786  787  788  789  790  791  792  793  794  795 796
797 798  799
 [800]  800  801  802  803  804  805  806  807  808  809  810  811  812 813
814 815  816
 [817]  817  818  819  820  821  822  823  824  825  826  827  828  829 830
831 832  833
 [834]  834  835  836  837  838  839  840  841  842  843  844  845  846 847
848 849  850
 [851]  851  852  853  854  855  856  857  858  859  860  861  862  863 864
865 866  867
 [868]  868  869  870  871  872  873  874  875  876  877  878  879  880 881
882 883  884
 [885]  885  886  887  888  889  890  891  892  893  894  895  896  897 898
899 900  901
 [902]  902  903  904  905  906  907  908  909  910  911  912  913  914 915
916 917  918
 [919]  919  920  921  922  923  924  925  926  927  928  929  930  931 932
933 934  935
 [936]  936  937  938  939  940  941  942  943  944  945  946  947  948 949
950 951  952
 [953]  953  954  955  956  957  958  959  960  961  962  963  964  965 966
967 968  969
 [970]  970  971  972  973  974  975  976  977  978  979  980  981  982 983
984 985  986
[987]  987  988  989  990  991  992  993  994  995  996  997  998  999 1000
```

Conclusion/Interpretation:

Trends and patterns in time series are hence checked.

i) Find out the most polluted time of the day and the name of the chemical compound

The R-script for the given problem is as follows:

```
names(AirQualityUCI)
library(dplyr)

polluted <- AirQualityUCI%>%group_by(Time)%>%
  select(Time, `CO(GT)`, `C6H6(GT)`, `NO2(GT)`, `NOx(GT)` )%>%
  summarise(CO = mean(`CO(GT)`), C6H6 = mean(`C6H6(GT)`), NO2 =
mean(`NO2(GT)`), NOX =mean(`NOx(GT)`))%>%


polluted[c(which.max(polluted$CO),which.max(polluted$C6H6),which.max(poll
uted$NO2),which.max(polluted$NOX)),]
```

The output of the R-Script (from Console window) is given as follows:

```
> names(AirQualityUCI)
 [1] "Date" "Time" "CO(GT)" "PT08.S1(CO)" "C6H6(GT)"

  [6] "PT08.S2(NMHC)" "NOx(GT)"       "PT08.S3(NOx)"  "NO2(GT)"
"PT08.S4(NO2)"
 [11] "PT08.S5(O3)"   "T"             "RH"            "AH"            "Date1"
 [16] "Time1"         "datetime"
> library(dplyr)
>
> polluted <- AirQualityUCI%>%group_by(Time)%>%
+   select(Time, `CO(GT)`, `C6H6(GT)`, `NO2(GT)`, `NOx(GT)` )%>%
+   summarise(CO = mean(`CO(GT)`), C6H6 = mean(`C6H6(GT)`), NO2
= mean(`NO2(GT)`), NOX =mean(`NOx(GT)`))%>%
+
+
polluted[c(which.max(polluted$CO),which.max(polluted$C6H6),which.max(polluted
$NO2),which.max(polluted$NOX)),]
```

Date	Time	CO(GT)	PT08.S1(CO)	NMHC(GT)	C6H6(GT)	PT08.S2(NMHC)
6/8/2004	8:00:00	5.8	1377	-200	36.1	1688
6/9/2004	8:00:00	6.4	1496	-200	36.9	1705
10/26/2004	18:00:00	9.5	1908	-200	52.1	2007
max		11.9	2039.8	1189.0	63.7	2214.0

Date	Time	NOx(GT)	PT08.S3(NOx)	NO2(GT)	PT08.S4(NO2)	PT08.S5(O3)
6/8/2004	8:00:00	376	525	125	2746	1708
6/9/2004	8:00:00	357	507	151	2691	2147
10/26/2004	18:00:00	952	325	180	2775	2372
max		1479.0	2682.8	339.7	2775.0	2522.8

Conclusion/Interpretation:

PT08.S4(NO2) is the highest pollution at 18.00 hrs