SIW004: Homework 1

H1: Looking at Multivariate data

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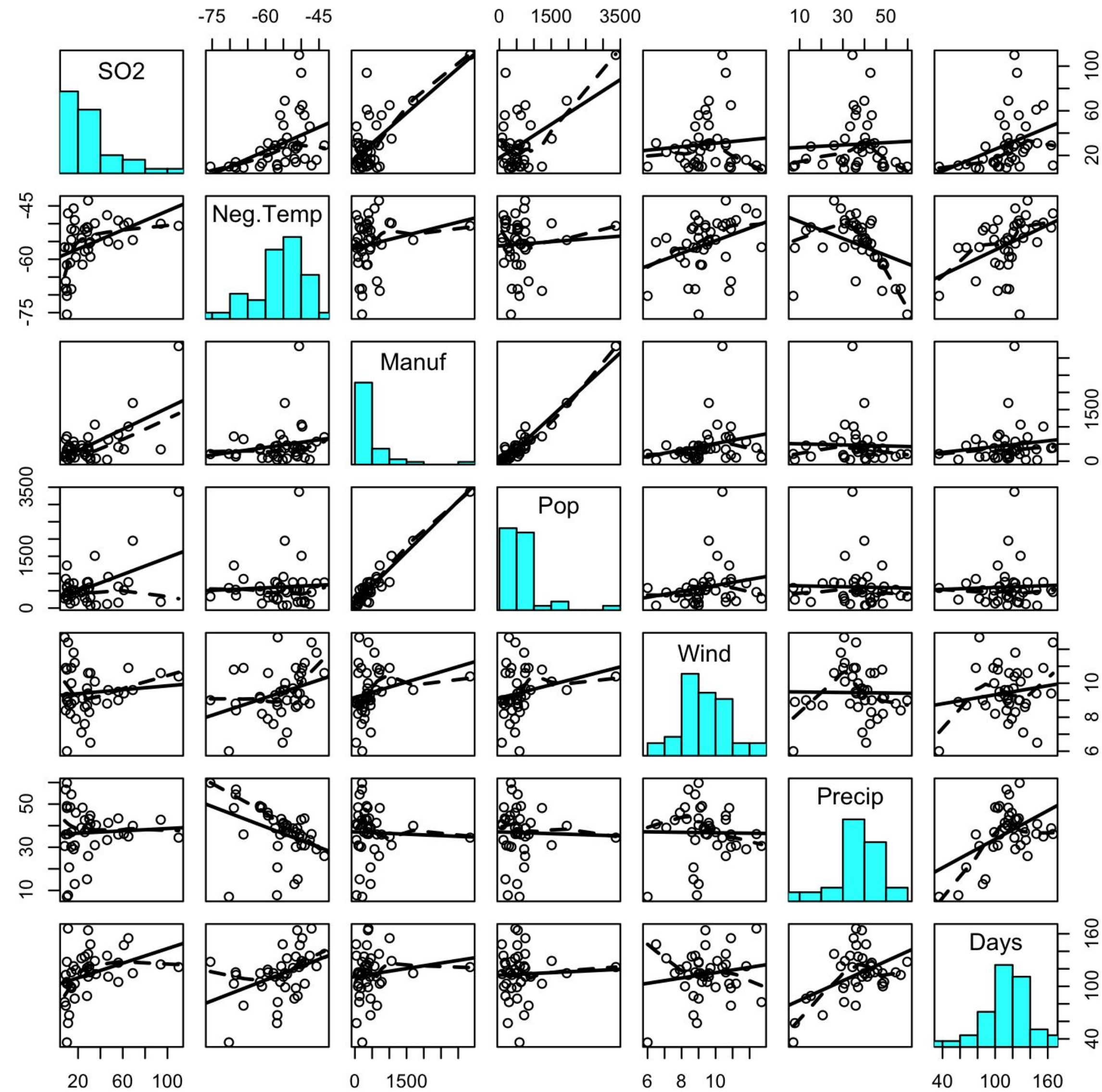
Deadline: send work by email to mateu@uji.es by January 8, 2017

Note: the answers to each of these questions should be written clearly reflecting your understanding of the statistical procedure followed, and you should include any R code you have written.

1) Present a complete description using the concepts learned in Chapter 2 in Everitt of the dataset: usair.dat

We begin with a scatterplot matrix to show an overview of how the data is correlated. In our graphs we show two lines a solid line representing the least squares fit (using the `lsfit` method of R) and a dotted line representing a locally-weighted polynomial regression, i.e. a smoothed line fitted locally (using the `lowess` method of R).

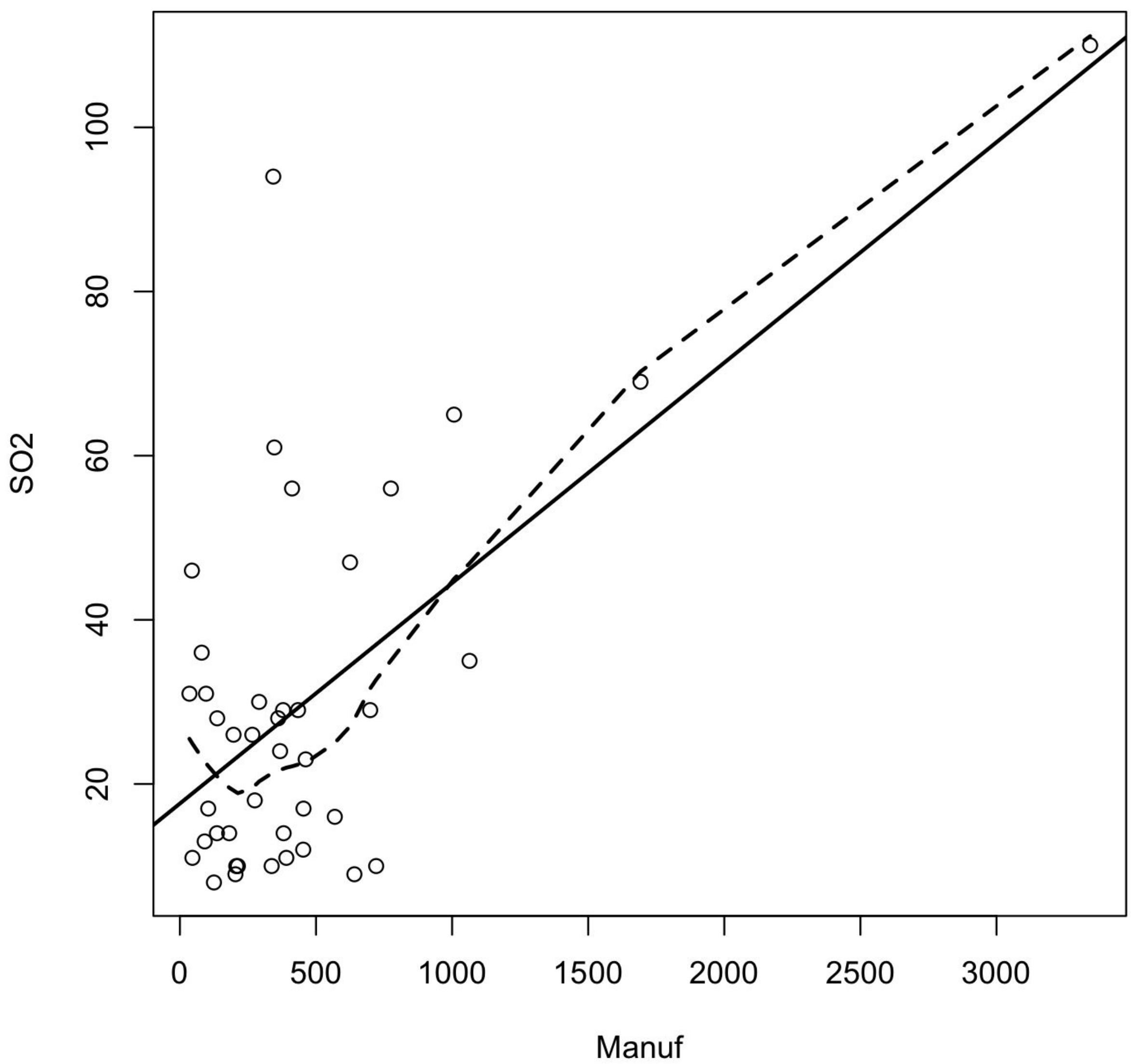
```
usair.dat<-source(paste(getwd(), "/Data/chap3usair.dat", sep = ""))$value

panel.hist <- function(x, ...)
{
   usr <- par("usr"); on.exit(par(usr))
   par(usr = c(usr[1:2], 0, 1.5) )
   h <- hist(x, plot = FALSE)
   breaks <- h$breaks; nB <- length(breaks)
   y <- h$counts; y <- y/max(y)
   rect(breaks[-nB], 0, breaks[-1], y, col = "cyan", ...)
}

pairs(usair.dat,panel=function(x,y) {abline(lsfit(x,y)$coef,lwd=2)
                                     lines(lowess(x,y),lty=2,lwd=2)
                                     points(x,y)}, diag.panel=panel.hist)
```



Some of these graphs are meaningless, such as population graphed against wind, but we still find it helpful to see a complete picture. Other graphs are uninteresting because they are obvious, such as the two graphs showing high correlation between population and manufacturing. It is not surprising that high-population cities contain more manufacturing.

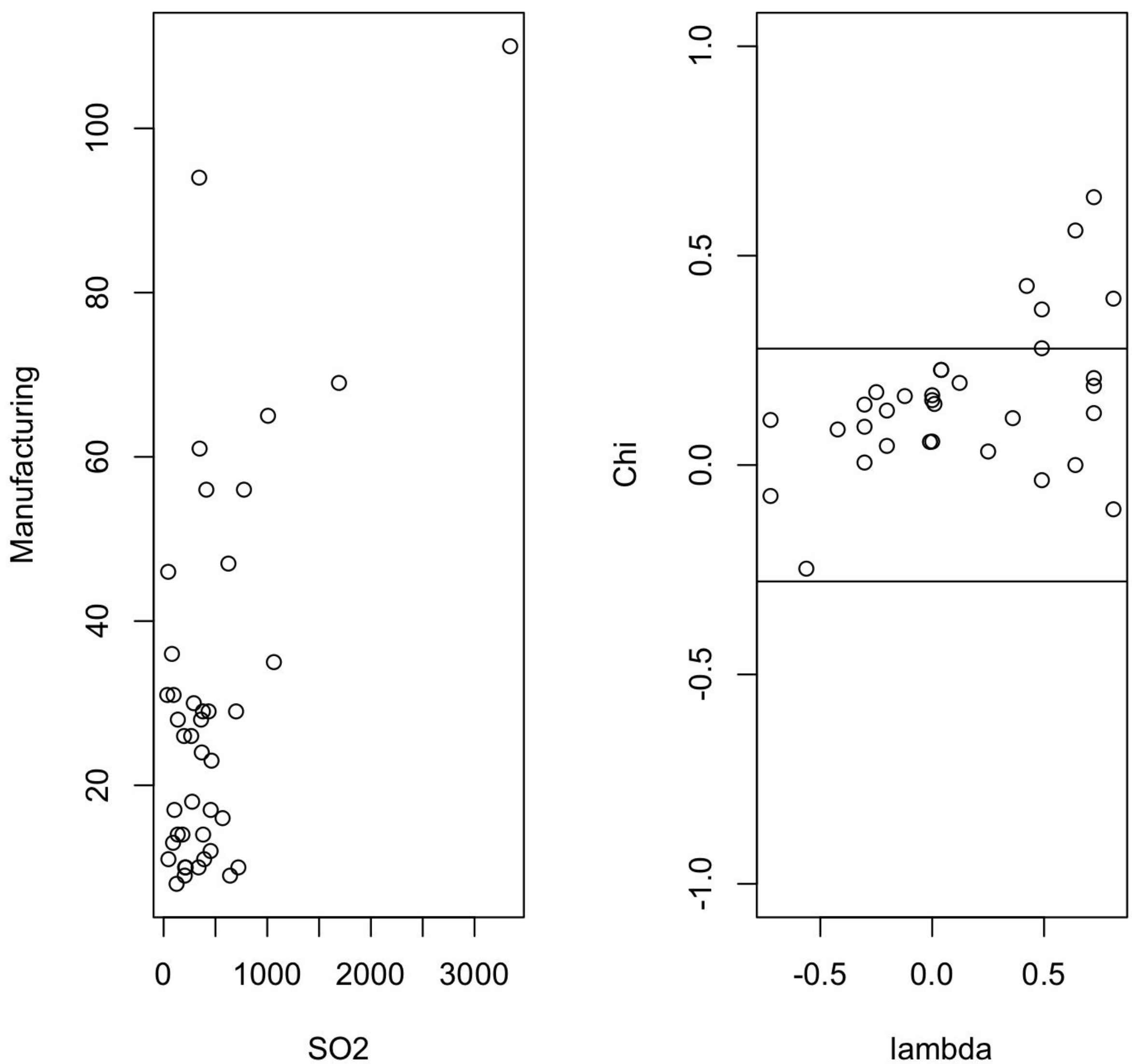
Other graphs show correlation that wasn't necessarily expected, such as SO2 against manufacturing, which we can now visualize in a larger format.

```
attach(usair.dat)
plot(Manuf, SO2)
abline(lsfit(Manuf, SO2), lwd=2)
abline(lines(lowess(Manuf, SO2), lty=2, lwd=2))
```



It seems from looking at this larger scatterplot like these two variables (SO2 and Manufacturing) might actually not be correlated, but let's make a chiplot just to double check.

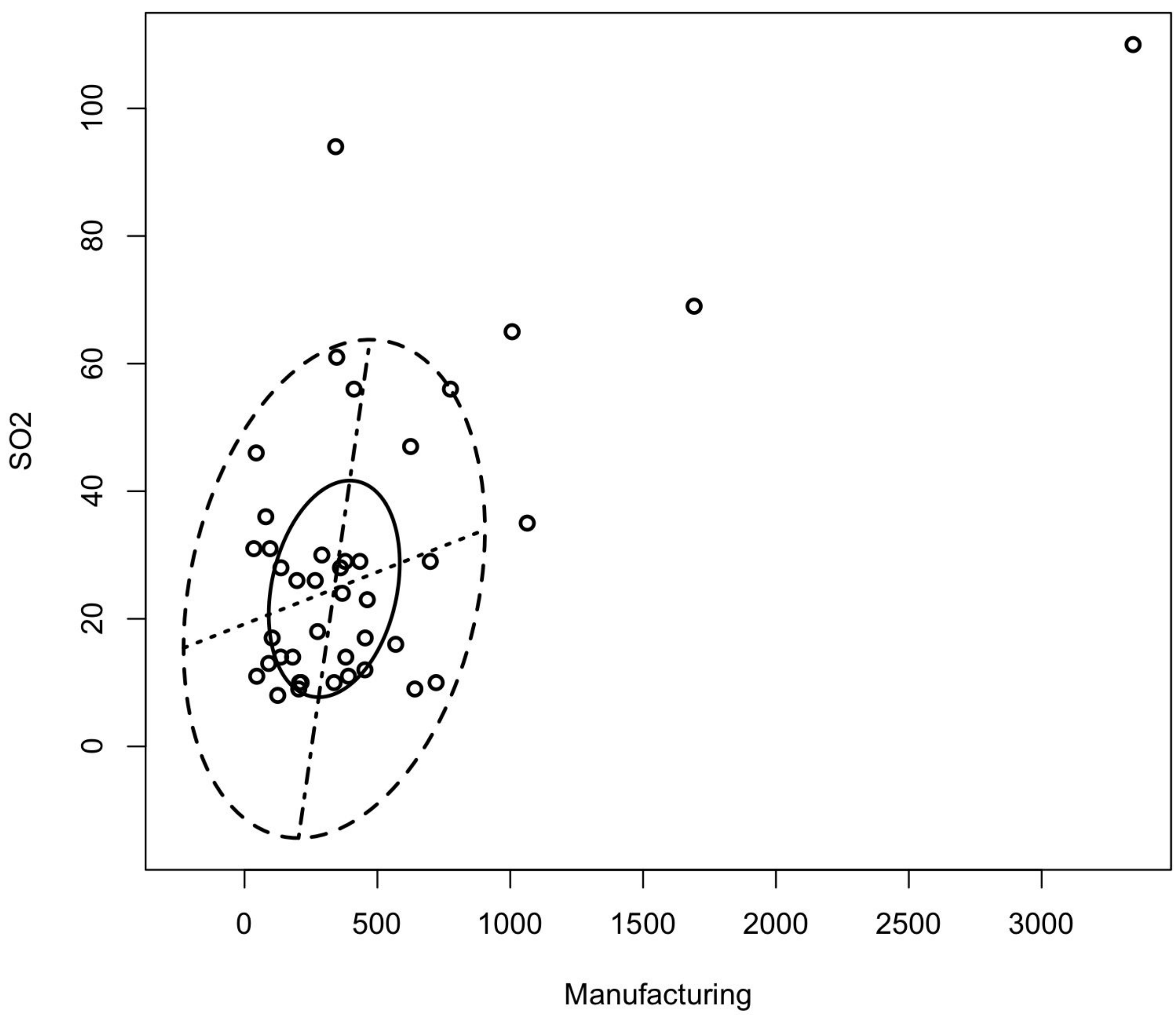
```
chiplot(Manuf, SO2, vlabs=c("SO2", "Manufacturing"))
```



This chiplot shows most of the values in the center, which indicates that indeed the values are *independent*, so it turns out our original hypothesis of correlation was false.

A bivariate boxplot shows the same conclusion.

```
source(paste(getwd(), "/functions.txt", sep="")) # Load functions from file
bvbox(cbind(Manuf, SO2), xlab="Manufacturing", ylab="SO2")
```



In this plot, the acute angle between the regression lines is large, which means that the absolute value of correlation between the two variables is small.

2) Using the matrix data of usair.dat, calculate the set of following distances:

a) Euclidean distances for original data

```
dis<-dist(usair.dat)
dis.matrix<-dist2full(dis)
round(dis.matrix,digits=2)
```

```
        [,1]    [,2]    [,3]    [,4]    [,5]    [,6]    [,7]    [,8]    [,9]
 [1,]    0.00  472.55  277.31  255.93  481.20  527.10  294.36  131.96  268.94
 [2,]  472.55    0.00  688.47  529.17  326.29   60.56  713.27  399.98  236.21
 [3,]  277.31  688.47    0.00  202.16  564.94  739.46   67.82  373.02  459.66
 [4,]  255.93  529.17  202.16    0.00  365.17  575.32  245.84  322.84  313.01
 [5,]  481.20  326.29  564.94  365.17    0.00  341.92  600.30  464.97  276.47
 [6,]  527.10   60.56  739.46  575.32  341.92    0.00  764.01  453.47  287.87
 [7,]  294.36  713.27   67.82  245.84  600.30  764.01    0.00  376.04  480.66
 [8,]  131.96  399.98  373.02  322.84  464.97  453.47  376.04    0.00  207.16
 [9,]  268.94  236.21  459.66  313.01  276.47  287.87  480.66  207.16    0.00
[10,]  198.69  458.59  241.71   99.77  343.81  507.05  268.52  234.59  229.91
[11,] 4193.93 4590.25 3925.45 4062.98 4348.58 4634.31 3911.19 4285.65 4365.46
[12,]  240.19  671.37  113.50  253.03  590.93  722.94   74.67  313.76  440.45
[13,]  403.27   73.62  623.31  470.87  314.60  125.77  646.82  331.25  175.45
[14,]  321.99  151.30  548.33  406.61  317.95  206.78  572.05  256.01  115.90
[15,]  125.28  503.39  212.93  187.39  452.33  554.81  217.97  169.47  273.35
[16,]  239.44  255.96  437.71  298.66  295.68  309.10  458.87  181.35   31.18
[17,]  531.50  940.24  262.48  428.58  777.02  988.83  242.32  618.03  708.55
[18,] 1265.40 1689.87 1006.51 1170.73 1503.90 1738.41  984.33 1353.12 1457.48
[19,]  523.54  864.09  258.25  339.78  653.40  908.27  267.26  604.40  641.84
[20,]  197.48  474.24  223.98   78.47  354.09  523.12  256.30  247.58  248.35
[21,]  570.41  842.63  340.78  341.93  589.62  881.64  367.81  647.58  639.21
[22,]  247.03  234.02  459.60  321.26  303.10  286.95  482.30  190.66   56.51
[23,]  377.90  134.22  623.44  490.69  386.61  181.32  646.39  308.24  205.33
[24,]  507.97   72.03  730.28  575.31  370.75   56.76  750.98  425.79  278.12
[25,]  253.32  451.98  279.28  116.96  311.58  496.81  302.91  269.62  230.36
[26,]  298.86  491.88  271.93   82.15  301.14  534.37  306.09  335.91  282.90
[27,]  823.05 1108.27  564.76  607.51  840.60 1145.49  575.91  901.54  904.49
[28,]  125.26  445.69  266.32  197.31  410.17  496.70  275.48  134.46  216.55
[29,] 2017.41 2423.18 1750.37 1896.35 2202.28 2469.12 1734.20 2108.03 2194.98
[30,]  194.89  469.96  242.35  132.95  368.44  516.36  257.12  220.07  240.78
[31,]  442.71  270.29  557.76  365.46   81.57  287.19  588.94  415.10  225.48
[32,]  154.13  550.11  155.57  165.47  474.94  602.39  166.19  222.80  318.21
[33,]  174.33  366.21  326.95  196.90  323.25  416.97  347.86  161.43  134.12
[34,]  504.45  900.08  228.44  379.57  726.63  949.01  228.03  596.72  671.27
[35,]  829.50 1268.54  584.23  767.26 1119.92 1319.61  556.41  915.46 1035.09
[36,]  417.36   74.90  626.31  464.27  281.03  117.44  653.34  356.91  186.06
[37,]  311.71  177.78  545.22  416.14  351.01  228.73  562.06  225.64  118.86
[38,]  297.09  198.91  492.35  338.44  259.28  248.54  515.73  238.79   49.32
[39,]  219.75  496.68  223.07  113.04  377.28  543.47  238.64  249.25  265.88
[40,]  554.21   97.89  773.36  614.43  388.35   57.40  794.47  470.79  317.65
[41,]  392.03  756.22  129.65  236.02  582.21  803.48  142.74  473.34  528.08
```

	[,10]	[,11]	[,12]	[,13]	[,14]	[,15]	[,16]	[,17]	[,18]
[1,]	198.69	4193.93	240.19	403.27	321.99	125.28	239.44	531.50	1265.40
[2,]	458.59	4590.25	671.37	73.62	151.30	503.39	255.96	940.24	1689.87
[3,]	241.71	3925.45	113.50	623.31	548.33	212.93	437.71	262.48	1006.51
[4,]	99.77	4062.98	253.03	470.87	406.61	187.39	298.66	428.58	1170.73
[5,]	343.81	4348.58	590.93	314.60	317.95	452.33	295.68	777.02	1503.90
[6,]	507.05	4634.31	722.94	125.77	206.78	554.81	309.10	988.83	1738.41
[7,]	268.52	3911.19	74.67	646.82	572.05	217.97	458.87	242.32	984.33
[8,]	234.59	4285.65	313.76	331.25	256.01	169.47	181.35	618.03	1353.12
[9,]	229.91	4365.46	440.45	175.45	115.90	273.35	31.18	708.55	1457.48
[10,]	0.00	4136.75	249.56	397.46	330.37	123.72	213.87	482.86	1231.84
[11,]	4136.75	0.00	3973.05	4532.42	4464.81	4127.16	4349.57	3669.93	2940.89
[12,]	249.56	3973.05	0.00	602.99	526.95	168.37	416.99	308.95	1040.52
[13,]	397.46	4532.42	602.99	0.00	82.46	435.21	191.88	876.45	1626.02
[14,]	330.37	4464.81	526.95	82.46	0.00	360.21	122.88	804.28	1553.19
[15,]	123.72	4127.16	168.37	435.21	360.21	0.00	249.56	457.54	1201.74
[16,]	213.87	4349.57	416.99	191.88	122.88	249.56	0.00	689.23	1438.28
[17,]	482.86	3669.93	308.95	876.45	804.28	457.54	689.23	0.00	750.32
[18,]	1231.84	2940.89	1040.52	1626.02	1553.19	1201.74	1438.28	750.32	0.00
[19,]	414.62	3727.41	338.74	806.37	742.45	435.78	627.90	181.02	851.32
[20,]	28.34	4120.70	241.27	412.87	344.69	127.94	231.19	468.18	1216.52
[21,]	427.30	3761.52	433.40	793.15	737.83	485.95	630.10	320.52	937.27
[22,]	241.44	4375.71	438.64	165.18	91.42	271.45	44.39	714.07	1463.10
[23,]	415.67	4545.01	597.05	88.73	91.92	433.20	210.27	881.70	1628.77
[24,]	501.44	4634.25	705.66	112.71	191.93	537.68	297.41	980.19	1729.79
[25,]	69.45	4144.49	288.69	393.76	335.47	171.02	221.54	504.52	1247.96
[26,]	105.87	4100.82	310.17	438.92	383.90	221.34	275.87	481.56	1219.12
[27,]	690.25	3509.79	647.99	1059.69	1005.61	734.83	895.90	414.69	765.17
[28,]	113.34	4181.45	227.24	377.17	303.58	60.21	193.10	512.94	1258.44
[29,]	1966.30	2178.17	1795.24	2362.99	2293.32	1950.86	2177.88	1493.66	766.03
[30,]	60.28	4135.44	230.32	405.85	339.78	100.39	224.35	476.50	1225.22
[31,]	326.98	4379.78	571.15	253.30	258.01	422.18	245.66	780.41	1517.57
[32,]	131.86	4072.80	127.41	483.49	407.76	62.24	295.00	404.25	1149.14
[33,]	105.42	4237.89	310.50	301.42	231.25	146.51	113.68	576.45	1325.69
[34,]	443.52	3700.57	300.69	838.35	766.74	433.75	652.63	81.65	793.76
[35,]	816.52	3384.30	606.45	1202.69	1126.97	771.69	1013.83	344.20	444.98
[36,]	397.88	4526.40	613.72	47.82	105.26	446.73	204.16	878.14	1627.51
[37,]	331.32	4463.82	512.04	110.34	60.81	345.43	123.28	797.85	1545.80
[38,]	261.72	4397.24	476.23	136.77	85.16	308.80	67.07	742.22	1491.97
[39,]	62.47	4105.34	220.00	434.12	369.20	115.37	251.29	451.16	1197.86
[40,]	541.86	4672.61	750.11	155.05	235.72	581.94	338.82	1022.39	1771.64
[41,]	299.26	3839.61	210.70	694.91	626.58	305.23	511.27	199.56	937.58

	[,19]	[,20]	[,21]	[,22]	[,23]	[,24]	[,25]	[,26]	[,27]
[1,]	523.54	197.48	570.41	247.03	377.90	507.97	253.32	298.86	823.05
[2,]	864.09	474.24	842.63	234.02	134.22	72.03	451.98	491.88	1108.27
[3,]	258.25	223.98	340.78	459.60	623.44	730.28	279.28	271.93	564.76
[4,]	339.78	78.47	341.93	321.26	490.69	575.31	116.96	82.15	607.51
[5,]	653.40	354.09	589.62	303.10	386.61	370.75	311.58	301.14	840.60
[6,]	908.27	523.12	881.64	286.95	181.32	56.76	496.81	534.37	1145.49
[7,]	267.26	256.30	367.81	482.30	646.39	750.98	302.91	306.09	575.91
[8,]	604.40	247.58	647.58	190.66	308.24	425.79	269.62	335.91	901.54
[9,]	641.84	248.35	639.21	56.51	205.33	278.12	230.36	282.90	904.49
[10,]	414.62	28.34	427.30	241.44	415.67	501.44	69.45	105.87	690.25
[11,]	3727.41	4120.70	3761.52	4375.71	4545.01	4634.25	4144.49	4100.82	3509.79
[12,]	338.74	241.27	433.40	438.64	597.05	705.66	288.69	310.17	647.99
[13,]	806.37	412.87	793.15	165.18	88.73	112.71	393.76	438.92	1059.69
[14,]	742.45	344.69	737.83	91.42	91.92	191.93	335.47	383.90	1005.61
[15,]	435.78	127.94	485.95	271.45	433.20	537.68	171.02	221.34	734.83
[16,]	627.90	231.19	630.10	44.39	210.27	297.41	221.54	275.87	895.90
[17,]	181.02	468.18	320.52	714.07	881.70	980.19	504.52	481.56	414.69
[18,]	851.32	1216.52	937.27	1463.10	1628.77	1729.79	1247.96	1219.12	765.17
[19,]	0.00	399.01	150.56	654.03	826.73	907.62	418.46	375.77	310.89
[20,]	399.01	0.00	412.63	256.24	428.89	518.49	81.21	103.25	676.15
[21,]	150.56	412.63	0.00	655.99	824.23	889.65	422.57	358.28	270.35
[22,]	654.03	256.24	655.99	0.00	176.00	273.04	249.49	302.54	922.70
[23,]	826.73	428.89	824.23	176.00	0.00	155.83	423.74	472.59	1092.56
[24,]	907.62	518.49	889.65	273.04	155.83	0.00	492.98	537.50	1153.85
[25,]	418.46	81.21	422.57	249.49	423.74	492.98	0.00	80.78	682.24
[26,]	375.77	103.25	358.28	302.54	472.59	537.50	80.78	0.00	623.03
[27,]	310.89	676.15	270.35	922.70	1092.56	1153.85	682.24	623.03	0.00
[28,]	478.87	125.28	517.27	214.40	378.02	479.05	151.12	214.50	771.74
[29,]	1562.97	1950.45	1613.93	2203.67	2372.22	2465.86	1977.32	1938.12	1381.48
[30,]	418.76	76.52	442.05	249.27	421.96	505.38	89.81	139.32	699.32
[31,]	671.31	340.82	620.32	248.51	324.17	309.63	302.63	307.20	877.43
[32,]	384.31	125.99	440.65	318.74	482.72	588.69	181.52	214.31	686.22
[33,]	518.17	123.46	531.07	140.77	315.11	406.11	127.31	187.79	794.58
[34,]	133.64	426.35	265.12	677.70	845.76	944.12	464.52	433.83	389.80
[35,]	492.20	801.90	615.37	1037.91	1198.98	1307.29	840.47	822.68	566.03
[36,]	800.59	412.17	779.39	178.00	119.35	122.60	391.88	429.89	1045.78
[37,]	744.82	348.55	748.65	98.13	108.31	201.05	337.90	394.17	1014.41
[38,]	671.57	278.51	662.92	56.55	174.69	240.60	259.88	307.03	929.33
[39,]	385.65	71.03	411.51	278.78	453.67	534.44	71.61	118.52	666.47
[40,]	945.69	559.04	923.96	316.90	199.11	51.16	530.33	573.22	1186.79
[41,]	134.20	283.14	231.39	536.76	708.59	798.69	313.25	285.42	443.26

	[,28]	[,29]	[,30]	[,31]	[,32]	[,33]	[,34]	[,35]	[,36]
[1,]	125.26	2017.41	194.89	442.71	154.13	174.33	504.45	829.50	417.36
[2,]	445.69	2423.18	469.96	270.29	550.11	366.21	900.08	1268.54	74.90
[3,]	266.32	1750.37	242.35	557.76	155.57	326.95	228.44	584.23	626.31
[4,]	197.31	1896.35	132.95	365.46	165.47	196.90	379.57	767.26	464.27
[5,]	410.17	2202.28	368.44	81.57	474.94	323.25	726.63	1119.92	281.03
[6,]	496.70	2469.12	516.36	287.19	602.39	416.97	949.01	1319.61	117.44
[7,]	275.48	1734.20	257.12	588.94	166.19	347.86	228.03	556.41	653.34
[8,]	134.46	2108.03	220.07	415.10	222.80	161.43	596.72	915.46	356.91
[9,]	216.55	2194.98	240.78	225.48	318.21	134.12	671.27	1035.09	186.06
[10,]	113.34	1966.30	60.28	326.98	131.86	105.42	443.52	816.52	397.88
[11,]	4181.45	2178.17	4135.44	4379.78	4072.80	4237.89	3700.57	3384.30	4526.40
[12,]	227.24	1795.24	230.32	571.15	127.41	310.50	300.69	606.45	613.72
[13,]	377.17	2362.99	405.85	253.30	483.49	301.42	838.35	1202.69	47.82
[14,]	303.58	2293.32	339.78	258.01	407.76	231.25	766.74	1126.97	105.26
[15,]	60.21	1950.86	100.39	422.18	62.24	146.51	433.75	771.69	446.73
[16,]	193.10	2177.88	224.35	245.66	295.00	113.68	652.63	1013.83	204.16
[17,]	512.94	1493.66	476.50	780.41	404.25	576.45	81.65	344.20	878.14
[18,]	1258.44	766.03	1225.22	1517.57	1149.14	1325.69	793.76	444.98	1627.51
[19,]	478.87	1562.97	418.76	671.31	384.31	518.17	133.64	492.20	800.59
[20,]	125.28	1950.45	76.52	340.82	125.99	123.46	426.35	801.90	412.17
[21,]	517.27	1613.93	442.05	620.32	440.65	531.07	265.12	615.37	779.39
[22,]	214.40	2203.67	249.27	248.51	318.74	140.77	677.70	1037.91	178.00
[23,]	378.02	2372.22	421.96	324.17	482.72	315.11	845.76	1198.98	119.35
[24,]	479.05	2465.86	505.38	309.63	588.69	406.11	944.12	1307.29	122.60
[25,]	151.12	1977.32	89.81	302.63	181.52	127.31	464.52	840.47	391.88
[26,]	214.50	1938.12	139.32	307.20	214.31	187.79	433.83	822.68	429.89
[27,]	771.74	1381.48	699.32	877.43	686.22	794.58	389.80	566.03	1045.78
[28,]	0.00	2005.94	91.42	375.49	115.94	94.75	486.51	830.01	389.41
[29,]	2005.94	0.00	1963.43	2226.43	1896.84	2065.57	1527.40	1208.65	2359.68
[30,]	91.42	1963.43	0.00	343.39	124.79	114.80	446.24	808.25	409.06
[31,]	375.49	2226.43	343.39	0.00	453.53	287.93	735.37	1123.27	221.05
[32,]	115.94	1896.84	124.79	453.53	0.00	187.34	376.49	720.00	492.49
[33,]	94.75	2065.57	114.80	287.93	187.34	0.00	541.01	903.09	308.30
[34,]	486.51	1527.40	446.24	735.37	376.49	541.01	0.00	398.13	837.49
[35,]	830.01	1208.65	808.25	1123.27	720.00	903.09	398.13	0.00	1208.40
[36,]	389.41	2359.68	409.06	221.05	492.49	308.30	837.49	1208.40	0.00
[37,]	288.44	2290.17	331.60	285.99	398.15	227.66	765.75	1116.68	144.17
[38,]	251.54	2227.71	271.46	201.27	354.46	168.46	704.23	1071.21	142.16
[39,]	117.32	1934.31	49.65	361.89	120.30	141.33	417.91	783.75	436.78
[40,]	523.04	2505.76	547.63	333.28	632.00	448.09	985.04	1350.40	159.99
[41,]	351.38	1668.68	301.29	588.91	251.98	399.13	154.45	539.17	693.42

	[,37]	[,38]	[,39]	[,40]	[,41]
[1,]	311.71	297.09	219.75	554.21	392.03
[2,]	177.78	198.91	496.68	97.89	756.22
[3,]	545.22	492.35	223.07	773.36	129.65
[4,]	416.14	338.44	113.04	614.43	236.02
[5,]	351.01	259.28	377.28	388.35	582.21
[6,]	228.73	248.54	543.47	57.40	803.48
[7,]	562.06	515.73	238.64	794.47	142.74
[8,]	225.64	238.79	249.25	470.79	473.34
[9,]	118.86	49.32	265.88	317.65	528.08
[10,]	331.32	261.72	62.47	541.86	299.26
[11,]	4463.82	4397.24	4105.34	4672.61	3839.61
[12,]	512.04	476.23	220.00	750.11	210.70
[13,]	110.34	136.77	434.12	155.05	694.91
[14,]	60.81	85.16	369.20	235.72	626.58
[15,]	345.43	308.80	115.37	581.94	305.23
[16,]	123.28	67.07	251.29	338.82	511.27
[17,]	797.85	742.22	451.16	1022.39	199.56
[18,]	1545.80	1491.97	1197.86	1771.64	937.58
[19,]	744.82	671.57	385.65	945.69	134.20
[20,]	348.55	278.51	71.03	559.04	283.14
[21,]	748.65	662.92	411.51	923.96	231.39
[22,]	98.13	56.55	278.78	316.90	536.76
[23,]	108.31	174.69	453.67	199.11	708.59
[24,]	201.05	240.60	534.44	51.16	798.69
[25,]	337.90	259.88	71.61	530.33	313.25
[26,]	394.17	307.03	118.52	573.22	285.42
[27,]	1014.41	929.33	666.47	1186.79	443.26
[28,]	288.44	251.54	117.32	523.04	351.38
[29,]	2290.17	2227.71	1934.31	2505.76	1668.68
[30,]	331.60	271.46	49.65	547.63	301.29
[31,]	285.99	201.27	361.89	333.28	588.91
[32,]	398.15	354.46	120.30	632.00	251.98
[33,]	227.66	168.46	141.33	448.09	399.13
[34,]	765.75	704.23	417.91	985.04	154.45
[35,]	1116.68	1071.21	783.75	1350.40	539.17
[36,]	144.17	142.16	436.78	159.99	693.42
[37,]	0.00	101.61	363.63	246.91	625.87
[38,]	101.61	0.00	299.03	281.70	560.02
[39,]	363.63	299.03	0.00	574.65	269.58
[40,]	246.91	281.70	574.65	0.00	838.79
[41,]	625.87	560.02	269.58	838.79	0.00

b) Euclidean distances for normalized data

```
usair.dat <- data.matrix(usair.dat)
std<-sd(usair.dat)
usair.dat.std<-sweep(usair.dat,2,std,FUN="/")
dis<-dist(usair.dat.std)
dis.matrix<-dist2full(dis)
round(dis.matrix,digits=2)
```

```
       [,1]  [,2]  [,3]  [,4]  [,5]  [,6]  [,7]  [,8]  [,9] [,10] [,11] [,12]
 [1,]  0.00  1.23  0.72  0.66  1.25  1.37  0.76  0.34  0.70  0.52 10.89  0.62
 [2,]  1.23  0.00  1.79  1.37  0.85  0.16  1.85  1.04  0.61  1.19 11.92  1.74
 [3,]  0.72  1.79  0.00  0.53  1.47  1.92  0.18  0.97  1.19  0.63 10.20  0.29
 [4,]  0.66  1.37  0.53  0.00  0.95  1.49  0.64  0.84  0.81  0.26 10.55  0.66
 [5,]  1.25  0.85  1.47  0.95  0.00  0.89  1.56  1.21  0.72  0.89 11.30  1.53
 [6,]  1.37  0.16  1.92  1.49  0.89  0.00  1.98  1.18  0.75  1.32 12.04  1.88
 [7,]  0.76  1.85  0.18  0.64  1.56  1.98  0.00  0.98  1.25  0.70 10.16  0.19
 [8,]  0.34  1.04  0.97  0.84  1.21  1.18  0.98  0.00  0.54  0.61 11.13  0.81
 [9,]  0.70  0.61  1.19  0.81  0.72  0.75  1.25  0.54  0.00  0.60 11.34  1.14
[10,]  0.52  1.19  0.63  0.26  0.89  1.32  0.70  0.61  0.60  0.00 10.75  0.65
[11,] 10.89 11.92 10.20 10.55 11.30 12.04 10.16 11.13 11.34 10.75  0.00 10.32
[12,]  0.62  1.74  0.29  0.66  1.53  1.88  0.19  0.81  1.14  0.65 10.32  0.00
[13,]  1.05  0.19  1.62  1.22  0.82  0.33  1.68  0.86  0.46  1.03 11.77  1.57
[14,]  0.84  0.39  1.42  1.06  0.83  0.54  1.49  0.67  0.30  0.86 11.60  1.37
[15,]  0.33  1.31  0.55  0.49  1.17  1.44  0.57  0.44  0.71  0.32 10.72  0.44
[16,]  0.62  0.66  1.14  0.78  0.77  0.80  1.19  0.47  0.08  0.56 11.30  1.08
[17,]  1.38  2.44  0.68  1.11  2.02  2.57  0.63  1.61  1.84  1.25  9.53  0.80
[18,]  3.29  4.39  2.61  3.04  3.91  4.52  2.56  3.51  3.79  3.20  7.64  2.70
[19,]  1.36  2.24  0.67  0.88  1.70  2.36  0.69  1.57  1.67  1.08  9.68  0.88
[20,]  0.51  1.23  0.58  0.20  0.92  1.36  0.67  0.64  0.65  0.07 10.70  0.63
[21,]  1.48  2.19  0.89  0.89  1.53  2.29  0.96  1.68  1.66  1.11  9.77  1.13
[22,]  0.64  0.61  1.19  0.83  0.79  0.75  1.25  0.50  0.15  0.63 11.37  1.14
[23,]  0.98  0.35  1.62  1.27  1.00  0.47  1.68  0.80  0.53  1.08 11.81  1.55
[24,]  1.32  0.19  1.90  1.49  0.96  0.15  1.95  1.11  0.72  1.30 12.04  1.83
[25,]  0.66  1.17  0.73  0.30  0.81  1.29  0.79  0.70  0.60  0.18 10.77  0.75
[26,]  0.78  1.28  0.71  0.21  0.78  1.39  0.80  0.87  0.73  0.28 10.65  0.81
[27,]  2.14  2.88  1.47  1.58  2.18  2.98  1.50  2.34  2.35  1.79  9.12  1.68
[28,]  0.33  1.16  0.69  0.51  1.07  1.29  0.72  0.35  0.56  0.29 10.86  0.59
[29,]  5.24  6.29  4.55  4.93  5.72  6.41  4.50  5.48  5.70  5.11  5.66  4.66
[30,]  0.51  1.22  0.63  0.35  0.96  1.34  0.67  0.57  0.63  0.16 10.74  0.60
[31,]  1.15  0.70  1.45  0.95  0.21  0.75  1.53  1.08  0.59  0.85 11.38  1.48
[32,]  0.40  1.43  0.40  0.43  1.23  1.56  0.43  0.58  0.83  0.34 10.58  0.33
[33,]  0.45  0.95  0.85  0.51  0.84  1.08  0.90  0.42  0.35  0.27 11.01  0.81
[34,]  1.31  2.34  0.59  0.99  1.89  2.47  0.59  1.55  1.74  1.15  9.61  0.78
[35,]  2.15  3.30  1.52  1.99  2.91  3.43  1.45  2.38  2.69  2.12  8.79  1.58
[36,]  1.08  0.19  1.63  1.21  0.73  0.31  1.70  0.93  0.48  1.03 11.76  1.59
[37,]  0.81  0.46  1.42  1.08  0.91  0.59  1.46  0.59  0.31  0.86 11.60  1.33
[38,]  0.77  0.52  1.28  0.88  0.67  0.65  1.34  0.62  0.13  0.68 11.42  1.24
[39,]  0.57  1.29  0.58  0.29  0.98  1.41  0.62  0.65  0.69  0.16 10.66  0.57
[40,]  1.44  0.25  2.01  1.60  1.01  0.15  2.06  1.22  0.83  1.41 12.14  1.95
[41,]  1.02  1.96  0.34  0.61  1.51  2.09  0.37  1.23  1.37  0.78  9.97  0.55
```

	[,13]	[,14]	[,15]	[,16]	[,17]	[,18]	[,19]	[,20]	[,21]	[,22]	[,23]	[,24]
[1,]	1.05	0.84	0.33	0.62	1.38	3.29	1.36	0.51	1.48	0.64	0.98	1.32
[2,]	0.19	0.39	1.31	0.66	2.44	4.39	2.24	1.23	2.19	0.61	0.35	0.19
[3,]	1.62	1.42	0.55	1.14	0.68	2.61	0.67	0.58	0.89	1.19	1.62	1.90
[4,]	1.22	1.06	0.49	0.78	1.11	3.04	0.88	0.20	0.89	0.83	1.27	1.49
[5,]	0.82	0.83	1.17	0.77	2.02	3.91	1.70	0.92	1.53	0.79	1.00	0.96
[6,]	0.33	0.54	1.44	0.80	2.57	4.52	2.36	1.36	2.29	0.75	0.47	0.15
[7,]	1.68	1.49	0.57	1.19	0.63	2.56	0.69	0.67	0.96	1.25	1.68	1.95
[8,]	0.86	0.67	0.44	0.47	1.61	3.51	1.57	0.64	1.68	0.50	0.80	1.11
[9,]	0.46	0.30	0.71	0.08	1.84	3.79	1.67	0.65	1.66	0.15	0.53	0.72
[10,]	1.03	0.86	0.32	0.56	1.25	3.20	1.08	0.07	1.11	0.63	1.08	1.30
[11,]	11.77	11.60	10.72	11.30	9.53	7.64	9.68	10.70	9.77	11.37	11.81	12.04
[12,]	1.57	1.37	0.44	1.08	0.80	2.70	0.88	0.63	1.13	1.14	1.55	1.83
[13,]	0.00	0.21	1.13	0.50	2.28	4.22	2.09	1.07	2.06	0.43	0.23	0.29
[14,]	0.21	0.00	0.94	0.32	2.09	4.03	1.93	0.90	1.92	0.24	0.24	0.50
[15,]	1.13	0.94	0.00	0.65	1.19	3.12	1.13	0.33	1.26	0.71	1.13	1.40
[16,]	0.50	0.32	0.65	0.00	1.79	3.74	1.63	0.60	1.64	0.12	0.55	0.77
[17,]	2.28	2.09	1.19	1.79	0.00	1.95	0.47	1.22	0.83	1.85	2.29	2.55
[18,]	4.22	4.03	3.12	3.74	1.95	0.00	2.21	3.16	2.43	3.80	4.23	4.49
[19,]	2.09	1.93	1.13	1.63	0.47	2.21	0.00	1.04	0.39	1.70	2.15	2.36
[20,]	1.07	0.90	0.33	0.60	1.22	3.16	1.04	0.00	1.07	0.67	1.11	1.35
[21,]	2.06	1.92	1.26	1.64	0.83	2.43	0.39	1.07	0.00	1.70	2.14	2.31
[22,]	0.43	0.24	0.71	0.12	1.85	3.80	1.70	0.67	1.70	0.00	0.46	0.71
[23,]	0.23	0.24	1.13	0.55	2.29	4.23	2.15	1.11	2.14	0.46	0.00	0.40
[24,]	0.29	0.50	1.40	0.77	2.55	4.49	2.36	1.35	2.31	0.71	0.40	0.00
[25,]	1.02	0.87	0.44	0.58	1.31	3.24	1.09	0.21	1.10	0.65	1.10	1.28
[26,]	1.14	1.00	0.57	0.72	1.25	3.17	0.98	0.27	0.93	0.79	1.23	1.40
[27,]	2.75	2.61	1.91	2.33	1.08	1.99	0.81	1.76	0.70	2.40	2.84	3.00
[28,]	0.98	0.79	0.16	0.50	1.33	3.27	1.24	0.33	1.34	0.56	0.98	1.24
[29,]	6.14	5.96	5.07	5.66	3.88	1.99	4.06	5.07	4.19	5.72	6.16	6.41
[30,]	1.05	0.88	0.26	0.58	1.24	3.18	1.09	0.20	1.15	0.65	1.10	1.31
[31,]	0.66	0.67	1.10	0.64	2.03	3.94	1.74	0.89	1.61	0.65	0.84	0.80
[32,]	1.26	1.06	0.16	0.77	1.05	2.98	1.00	0.33	1.14	0.83	1.25	1.53
[33,]	0.78	0.60	0.38	0.30	1.50	3.44	1.35	0.32	1.38	0.37	0.82	1.05
[34,]	2.18	1.99	1.13	1.70	0.21	2.06	0.35	1.11	0.69	1.76	2.20	2.45
[35,]	3.12	2.93	2.00	2.63	0.89	1.16	1.28	2.08	1.60	2.70	3.11	3.40
[36,]	0.12	0.27	1.16	0.53	2.28	4.23	2.08	1.07	2.02	0.46	0.31	0.32
[37,]	0.29	0.16	0.90	0.32	2.07	4.02	1.93	0.91	1.94	0.25	0.28	0.52
[38,]	0.36	0.22	0.80	0.17	1.93	3.88	1.74	0.72	1.72	0.15	0.45	0.62
[39,]	1.13	0.96	0.30	0.65	1.17	3.11	1.00	0.18	1.07	0.72	1.18	1.39
[40,]	0.40	0.61	1.51	0.88	2.66	4.60	2.46	1.45	2.40	0.82	0.52	0.13
[41,]	1.81	1.63	0.79	1.33	0.52	2.44	0.35	0.74	0.60	1.39	1.84	2.07

	[,25]	[,26]	[,27]	[,28]	[,29]	[,30]	[,31]	[,32]	[,33]	[,34]	[,35]	[,36]
[1,]	0.66	0.78	2.14	0.33	5.24	0.51	1.15	0.40	0.45	1.31	2.15	1.08
[2,]	1.17	1.28	2.88	1.16	6.29	1.22	0.70	1.43	0.95	2.34	3.30	0.19
[3,]	0.73	0.71	1.47	0.69	4.55	0.63	1.45	0.40	0.85	0.59	1.52	1.63
[4,]	0.30	0.21	1.58	0.51	4.93	0.35	0.95	0.43	0.51	0.99	1.99	1.21
[5,]	0.81	0.78	2.18	1.07	5.72	0.96	0.21	1.23	0.84	1.89	2.91	0.73
[6,]	1.29	1.39	2.98	1.29	6.41	1.34	0.75	1.56	1.08	2.47	3.43	0.31
[7,]	0.79	0.80	1.50	0.72	4.50	0.67	1.53	0.43	0.90	0.59	1.45	1.70
[8,]	0.70	0.87	2.34	0.35	5.48	0.57	1.08	0.58	0.42	1.55	2.38	0.93
[9,]	0.60	0.73	2.35	0.56	5.70	0.63	0.59	0.83	0.35	1.74	2.69	0.48
[10,]	0.18	0.28	1.79	0.29	5.11	0.16	0.85	0.34	0.27	1.15	2.12	1.03
[11,]	10.77	10.65	9.12	10.86	5.66	10.74	11.38	10.58	11.01	9.61	8.79	11.76
[12,]	0.75	0.81	1.68	0.59	4.66	0.60	1.48	0.33	0.81	0.78	1.58	1.59
[13,]	1.02	1.14	2.75	0.98	6.14	1.05	0.66	1.26	0.78	2.18	3.12	0.12
[14,]	0.87	1.00	2.61	0.79	5.96	0.88	0.67	1.06	0.60	1.99	2.93	0.27
[15,]	0.44	0.57	1.91	0.16	5.07	0.26	1.10	0.16	0.38	1.13	2.00	1.16
[16,]	0.58	0.72	2.33	0.50	5.66	0.58	0.64	0.77	0.30	1.70	2.63	0.53
[17,]	1.31	1.25	1.08	1.33	3.88	1.24	2.03	1.05	1.50	0.21	0.89	2.28
[18,]	3.24	3.17	1.99	3.27	1.99	3.18	3.94	2.98	3.44	2.06	1.16	4.23
[19,]	1.09	0.98	0.81	1.24	4.06	1.09	1.74	1.00	1.35	0.35	1.28	2.08
[20,]	0.21	0.27	1.76	0.33	5.07	0.20	0.89	0.33	0.32	1.11	2.08	1.07
[21,]	1.10	0.93	0.70	1.34	4.19	1.15	1.61	1.14	1.38	0.69	1.60	2.02
[22,]	0.65	0.79	2.40	0.56	5.72	0.65	0.65	0.83	0.37	1.76	2.70	0.46
[23,]	1.10	1.23	2.84	0.98	6.16	1.10	0.84	1.25	0.82	2.20	3.11	0.31
[24,]	1.28	1.40	3.00	1.24	6.41	1.31	0.80	1.53	1.05	2.45	3.40	0.32
[25,]	0.00	0.21	1.77	0.39	5.14	0.23	0.79	0.47	0.33	1.21	2.18	1.02
[26,]	0.21	0.00	1.62	0.56	5.03	0.36	0.80	0.56	0.49	1.13	2.14	1.12
[27,]	1.77	1.62	0.00	2.00	3.59	1.82	2.28	1.78	2.06	1.01	1.47	2.72
[28,]	0.39	0.56	2.00	0.00	5.21	0.24	0.98	0.30	0.25	1.26	2.16	1.01
[29,]	5.14	5.03	3.59	5.21	0.00	5.10	5.78	4.93	5.37	3.97	3.14	6.13
[30,]	0.23	0.36	1.82	0.24	5.10	0.00	0.89	0.32	0.30	1.16	2.10	1.06
[31,]	0.79	0.80	2.28	0.98	5.78	0.89	0.00	1.18	0.75	1.91	2.92	0.57
[32,]	0.47	0.56	1.78	0.30	4.93	0.32	1.18	0.00	0.49	0.98	1.87	1.28
[33,]	0.33	0.49	2.06	0.25	5.37	0.30	0.75	0.49	0.00	1.41	2.35	0.80
[34,]	1.21	1.13	1.01	1.26	3.97	1.16	1.91	0.98	1.41	0.00	1.03	2.18
[35,]	2.18	2.14	1.47	2.16	3.14	2.10	2.92	1.87	2.35	1.03	0.00	3.14
[36,]	1.02	1.12	2.72	1.01	6.13	1.06	0.57	1.28	0.80	2.18	3.14	0.00
[37,]	0.88	1.02	2.63	0.75	5.95	0.86	0.74	1.03	0.59	1.99	2.90	0.37
[38,]	0.68	0.80	2.41	0.65	5.79	0.71	0.52	0.92	0.44	1.83	2.78	0.37
[39,]	0.19	0.31	1.73	0.30	5.02	0.13	0.94	0.31	0.37	1.09	2.04	1.13
[40,]	1.38	1.49	3.08	1.36	6.51	1.42	0.87	1.64	1.16	2.56	3.51	0.42
[41,]	0.81	0.74	1.15	0.91	4.33	0.78	1.53	0.65	1.04	0.40	1.40	1.80

	[,37]	[,38]	[,39]	[,40]	[,41]
[1,]	0.81	0.77	0.57	1.44	1.02
[2,]	0.46	0.52	1.29	0.25	1.96
[3,]	1.42	1.28	0.58	2.01	0.34
[4,]	1.08	0.88	0.29	1.60	0.61
[5,]	0.91	0.67	0.98	1.01	1.51
[6,]	0.59	0.65	1.41	0.15	2.09
[7,]	1.46	1.34	0.62	2.06	0.37
[8,]	0.59	0.62	0.65	1.22	1.23
[9,]	0.31	0.13	0.69	0.83	1.37
[10,]	0.86	0.68	0.16	1.41	0.78
[11,]	11.60	11.42	10.66	12.14	9.97
[12,]	1.33	1.24	0.57	1.95	0.55
[13,]	0.29	0.36	1.13	0.40	1.81
[14,]	0.16	0.22	0.96	0.61	1.63
[15,]	0.90	0.80	0.30	1.51	0.79
[16,]	0.32	0.17	0.65	0.88	1.33
[17,]	2.07	1.93	1.17	2.66	0.52
[18,]	4.02	3.88	3.11	4.60	2.44
[19,]	1.93	1.74	1.00	2.46	0.35
[20,]	0.91	0.72	0.18	1.45	0.74
[21,]	1.94	1.72	1.07	2.40	0.60
[22,]	0.25	0.15	0.72	0.82	1.39
[23,]	0.28	0.45	1.18	0.52	1.84
[24,]	0.52	0.62	1.39	0.13	2.07
[25,]	0.88	0.68	0.19	1.38	0.81
[26,]	1.02	0.80	0.31	1.49	0.74
[27,]	2.63	2.41	1.73	3.08	1.15
[28,]	0.75	0.65	0.30	1.36	0.91
[29,]	5.95	5.79	5.02	6.51	4.33
[30,]	0.86	0.71	0.13	1.42	0.78
[31,]	0.74	0.52	0.94	0.87	1.53
[32,]	1.03	0.92	0.31	1.64	0.65
[33,]	0.59	0.44	0.37	1.16	1.04
[34,]	1.99	1.83	1.09	2.56	0.40
[35,]	2.90	2.78	2.04	3.51	1.40
[36,]	0.37	0.37	1.13	0.42	1.80
[37,]	0.00	0.26	0.94	0.64	1.63
[38,]	0.26	0.00	0.78	0.73	1.45
[39,]	0.94	0.78	0.00	1.49	0.70
[40,]	0.64	0.73	1.49	0.00	2.18
[41,]	1.63	1.45	0.70	2.18	0.00

c) Mahalanobis distances for the original data

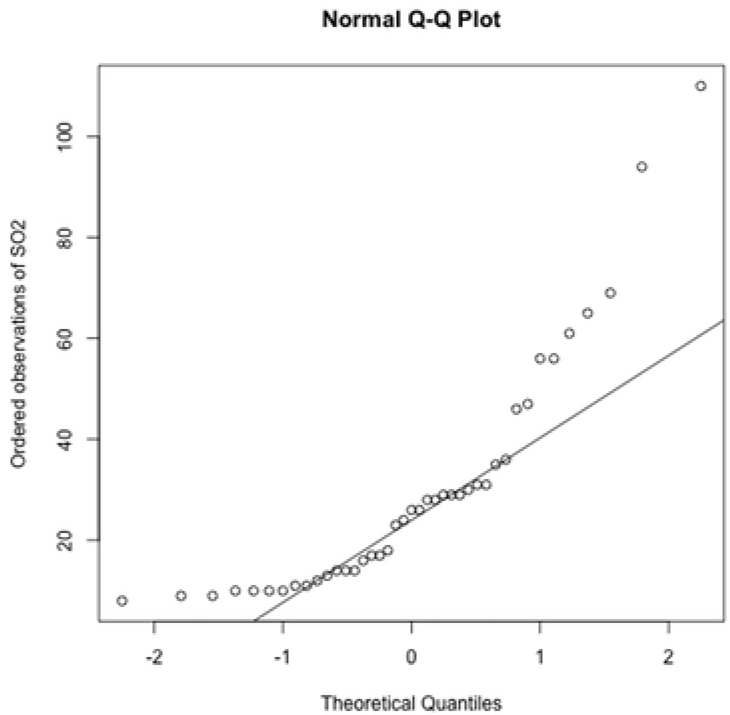
```
Sx <- cov(usair.dat)
mdis <- mahalanobis(usair.dat, colMeans(usair.dat), Sx)
```

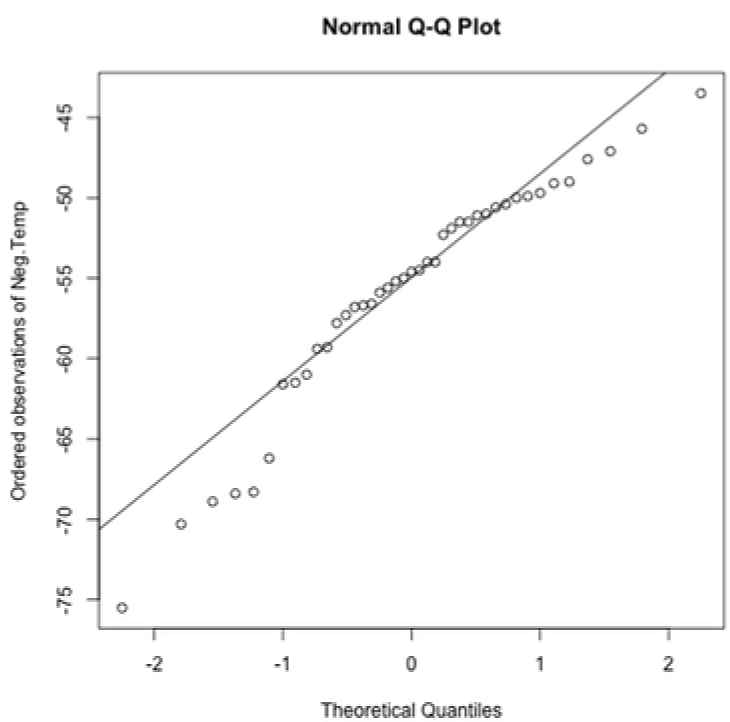
```
              Phoenix          Little Rock        San Francisco 
            20.258912             6.207429             4.539210 
               Denver             Hartford           Wilmington 
             5.400965             7.760199             2.156830 
           Washington         Jacksonville                Miami 
             1.538300             5.286583            14.277037 
              Atlanta              Chicago         Indianapolis 
             1.448871            26.891450             4.270100 
           Des Moines              Wichita           Louisville 
             4.310154             9.060638             3.060861 
          New Orleans            Baltimore              Detroit 
             5.394046             3.421276             7.222633 
Minneapolis-St. Paul          Kansas City            St. Louis 
             4.945830             3.060650             4.767204 
                Omaha          Alburquerque               Albany 
             3.052545             8.063093             4.081128 
              Buffalo           Cincinnati            Cleveland 
            12.880983             7.265585            11.489013 
             Columbus         Philadelphia           Pittsburgh 
             3.145760             6.722708             7.955753 
           Providence              Memphis            Nashville 
            18.176040             3.573384             2.564959 
               Dallas              Houston       Salt Lake City 
             6.368290             8.684843             4.431380 
              Norfolk             Richmond              Seattle 
             3.754730             2.492672             6.535345 
           Charleston            Milwaukee 
             7.888784             5.593824 
```

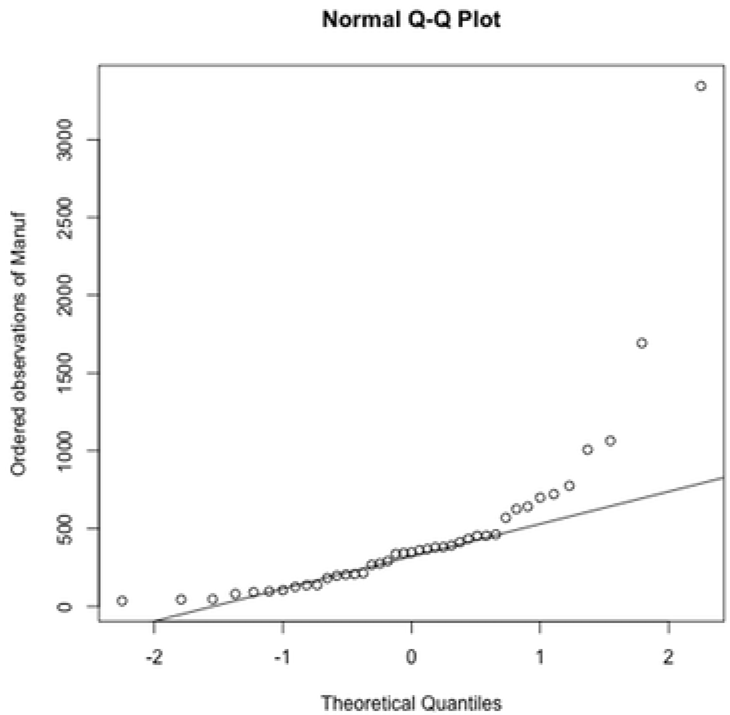
3) Show the Q-Q plots of individual variables for usair dataset and explain the results.

None of the Q-Q plots show extremely normal distribution of the observations, which would result in the points being aligned linearly. Only Wind and Neg.Temp look somewhat linear, as you might also expect if you look at the histograms in our original scatterplot matrix. The histograms for Wind and Neg.Temp look similar to a bell curve there, so it follows that the Q-Q plots for these variables do not give much indication of a departure from linearity.

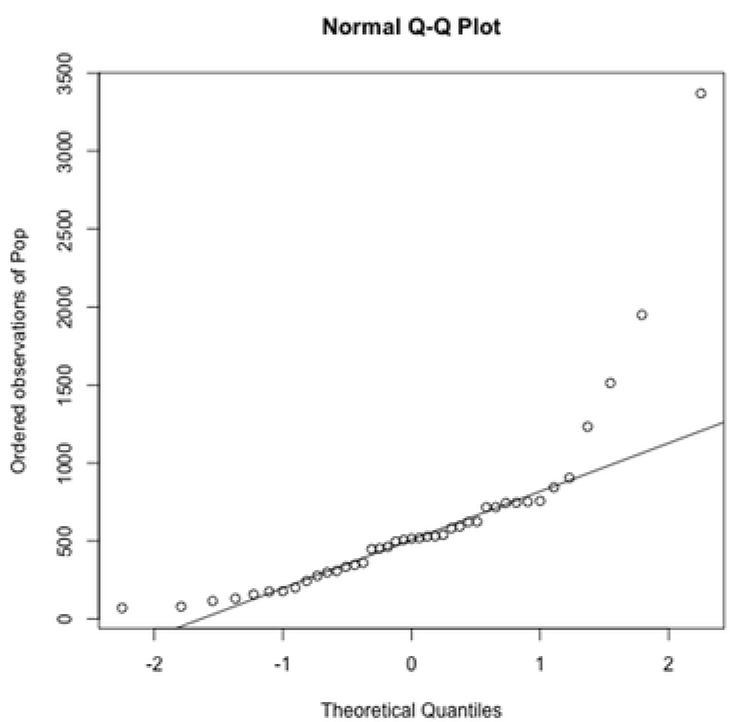
```
qqnorm(usair.dat[,1],ylab="Ordered observations of SO2")
qqline(usair.dat[,1])
dev.copy(png,'3.1.SO2_Neg.Temp.png')
dev.off()

qqnorm(usair.dat[,2],ylab="Ordered observations of Neg.Temp")
qqline(usair.dat[,2])
dev.copy(png,'3.2.SO2_Manuf.png')
dev.off()

qqnorm(usair.dat[,3],ylab="Ordered observations of Manuf")
qqline(usair.dat[,3])
dev.copy(png,'3.3.SO2_Neg.Temp.png')
dev.off()

qqnorm(usair.dat[,4],ylab="Ordered observations of Pop")
qqline(usair.dat[,4])
dev.copy(png,'3.4.SO2_Neg.Temp.png')
dev.off()

qqnorm(usair.dat[,5],ylab="Ordered observations of Wind")
qqline(usair.dat[,5])
dev.copy(png,'3.5.SO2_Neg.Temp.png')
dev.off()

qqnorm(usair.dat[,6],ylab="Ordered observations of Precip")
qqline(usair.dat[,6])
dev.copy(png,'3.6.SO2_Neg.Temp.png')
dev.off()

qqnorm(usair.dat[,7],ylab="Ordered observations of Days")
qqline(usair.dat[,7])
dev.copy(png,'3.7.SO2_Neg.Temp.png')
dev.off()
```


Normal Q-Q Plot
Ordered observations of SO2
Theoretical Quantiles
20
40
60
80
100
-2
-1
0
1
2

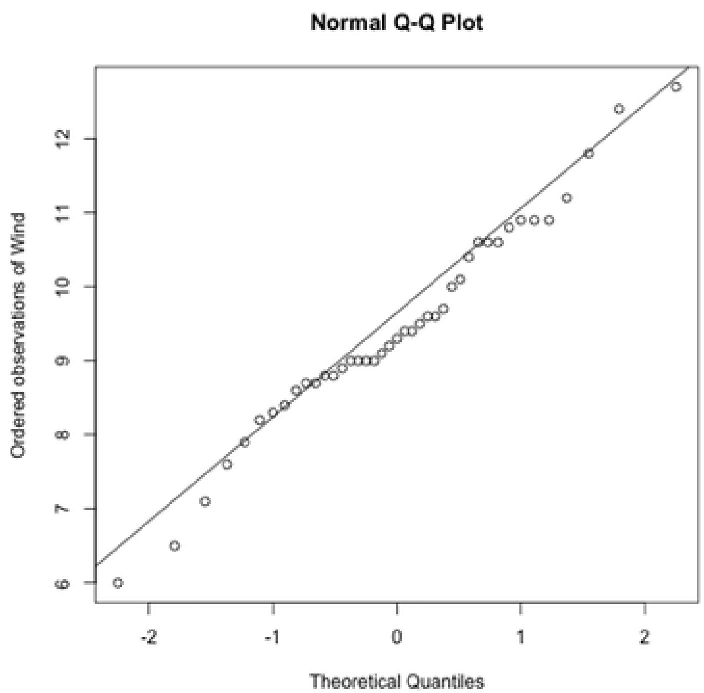

Normal Q-Q Plot
Ordered observations of Neg.Temp
Theoretical Quantiles
-75
-70
-65
-60
-55
-50
-45
-2
-1
0
1
2

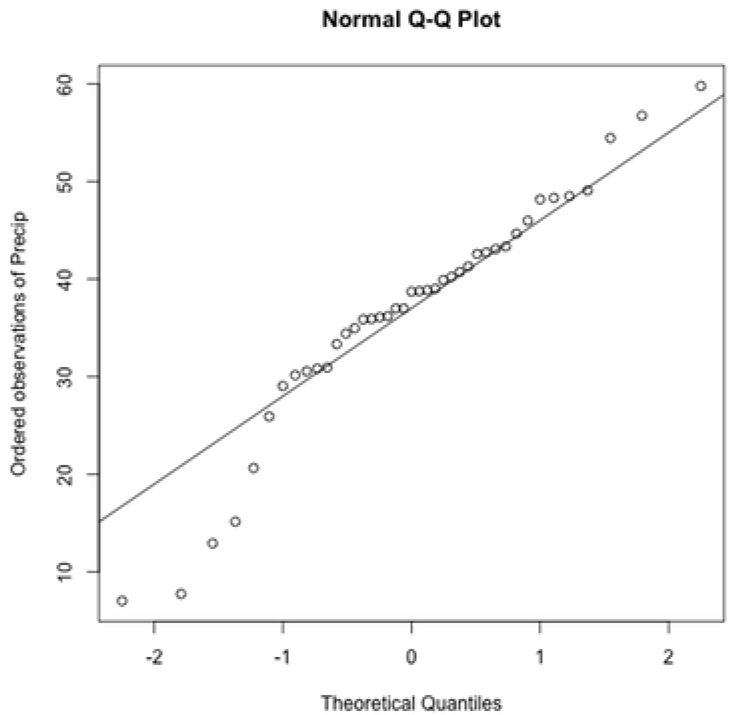


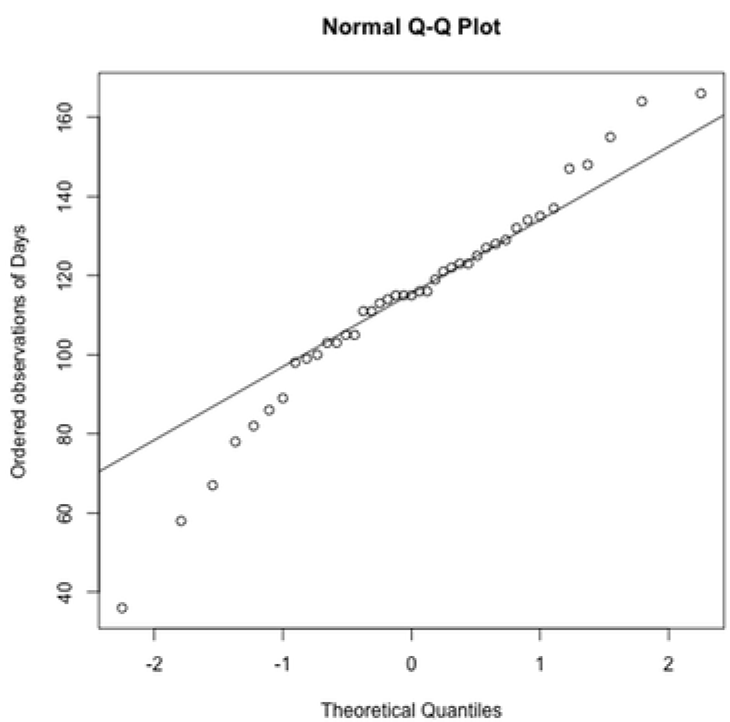
Normal Q-Q Plot
Ordered observations of Manuf
0
500
1000
1500
2000
2500
3000
-2
-1
0
1
2
Theoretical Quantiles



Normal Q-Q Plot
Ordered observations of Pop
0
500
1000
1500
2000
2500
3000
3500
-2
-1
0
1
2
Theoretical Quantiles


Normal Q-Q Plot
Ordered observations of Wind
Theoretical Quantiles
6
7
8
9
10
11
12
-2
-1
0
1
2


Normal Q-Q Plot
Ordered observations of Precip
Theoretical Quantiles
60
50
40
30
20
10
-2
-1
0
1
2


Normal Q-Q Plot
Ordered observations of Days
Theoretical Quantiles
160
140
120
100
80
60
40
-2
-1
0
1
2

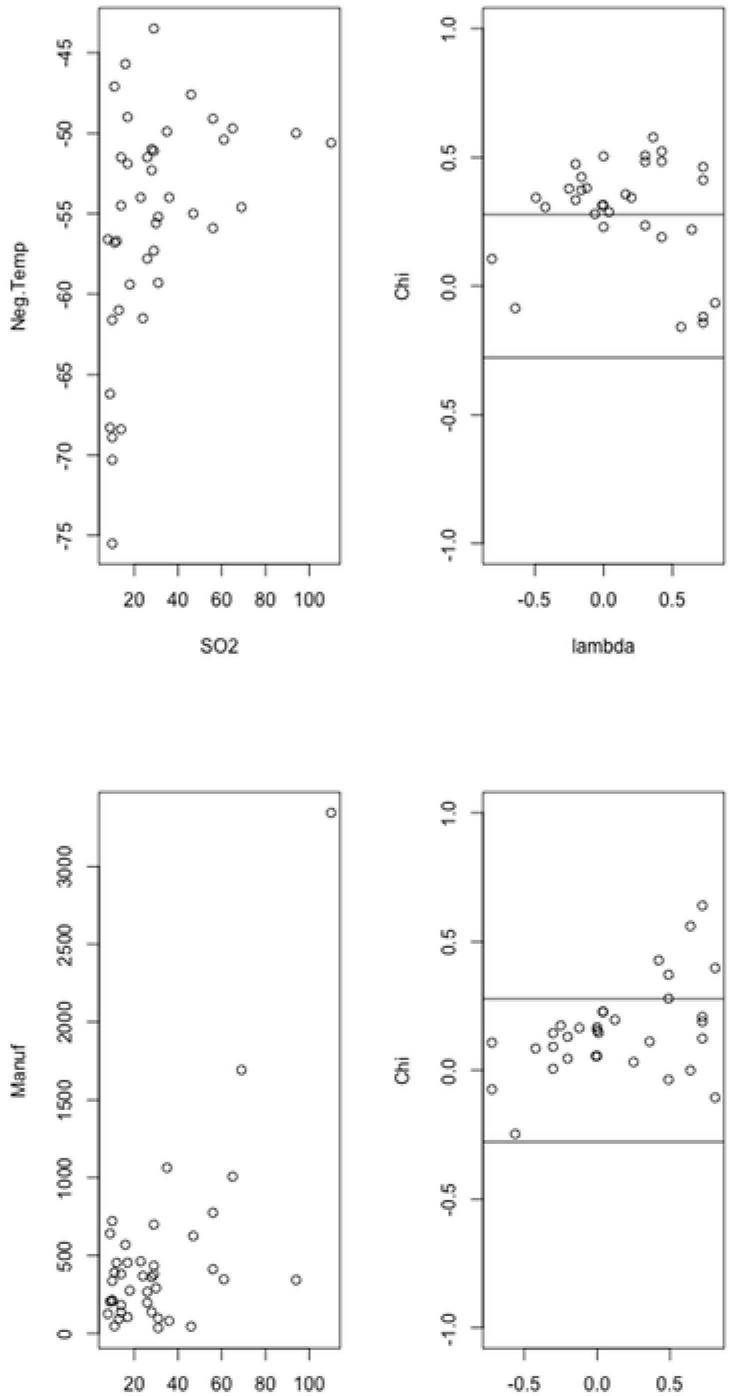
4) Solve exercise 2.6 in page 40 of Everitt's book.

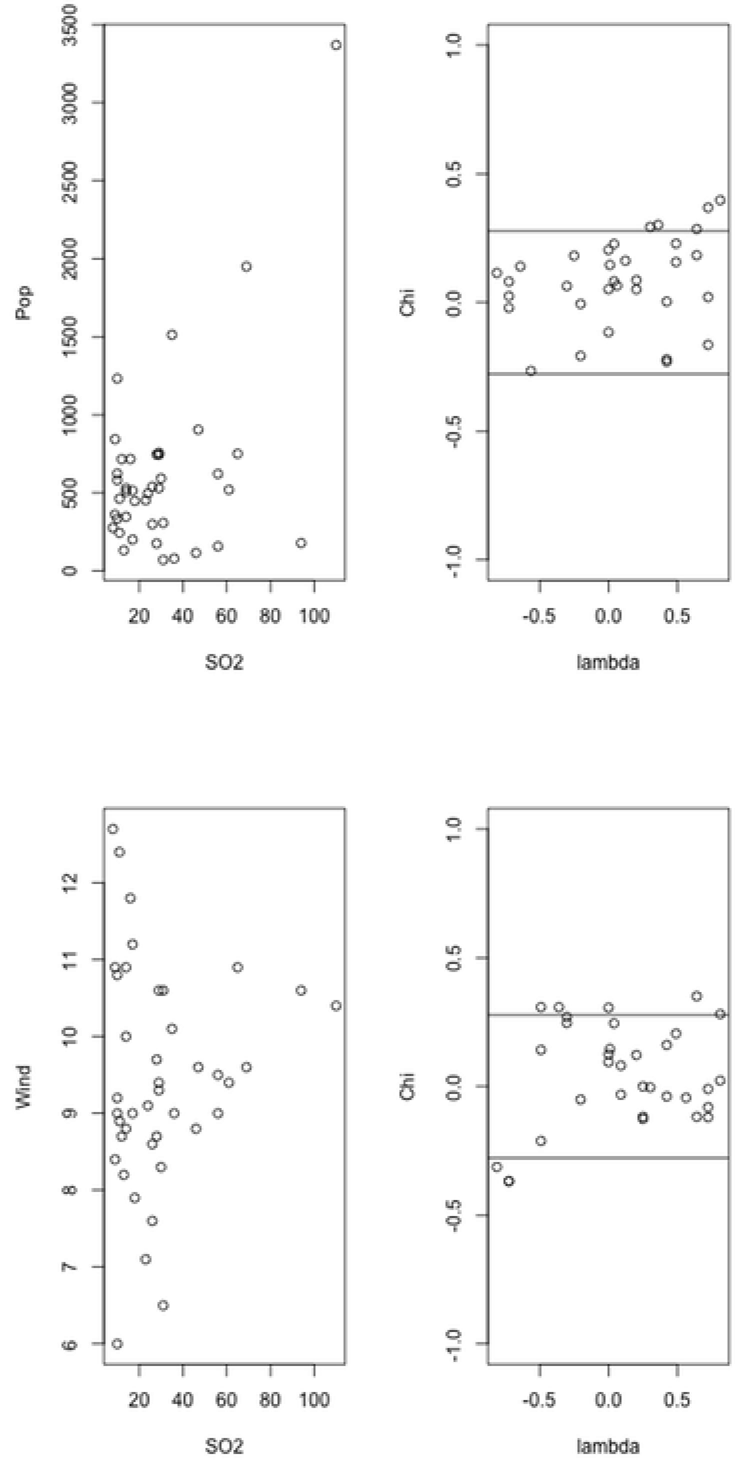
2.6 Investigate the use of the chiplot function on all pairs of variables in the air pollution data.

Investigating the data using chiplots reveals dependence between only two of the variable pairs. The first is Manuf and Pop: all but one of the points lies outside of the central bars. The second is SO2 and Neg.Temp, although in this case several points are still within the central bars. All other variable pairs appear to be independent.

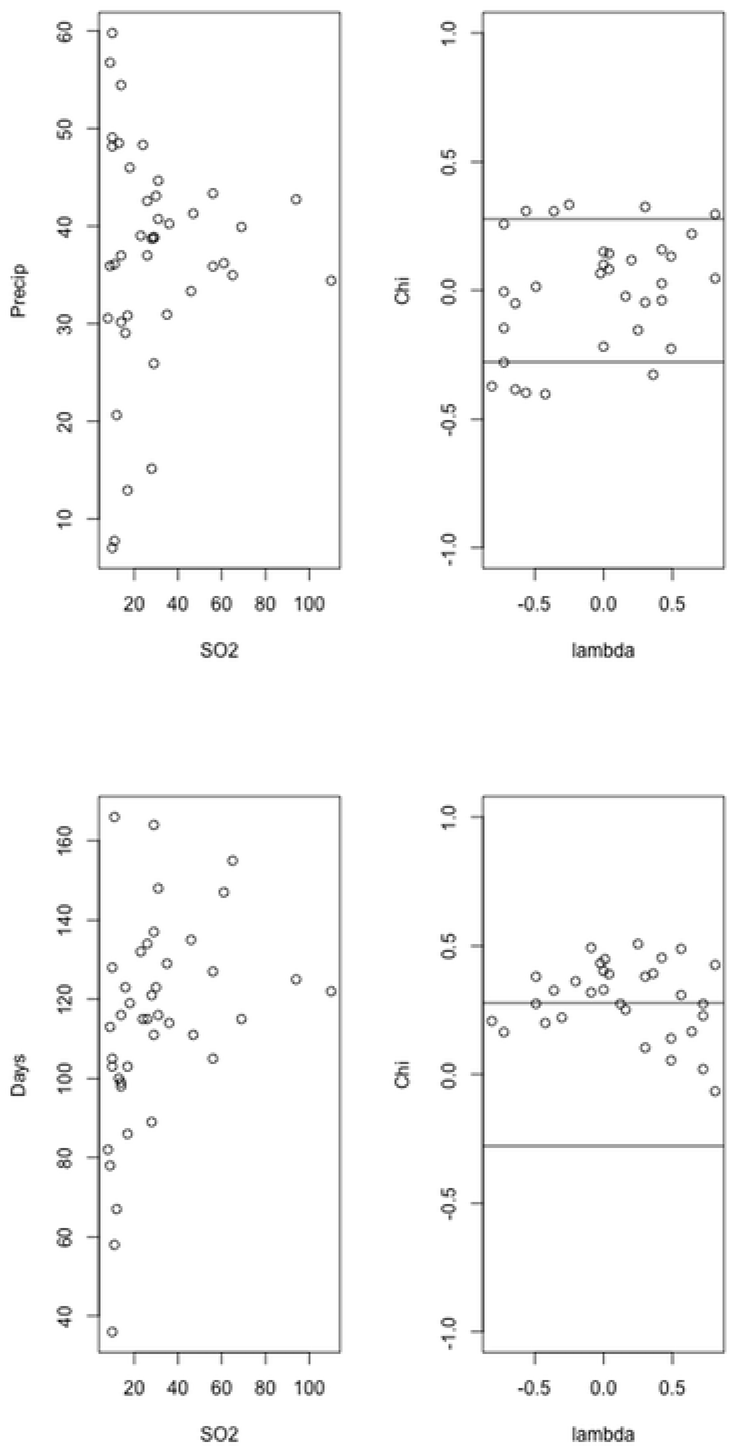
```
chiplot(SO2, Neg.Temp, vlabs=c("SO2", "Neg.Temp"))
dev.copy(png,'4.1.SO2_Neg.Temp.png')
dev.off()
chiplot(SO2, Manuf, vlabs=c("SO2", "Manuf"))
dev.copy(png,'4.2.SO2_Manuf.png')
dev.off()
chiplot(SO2, Pop, vlabs=c("SO2", "Pop"))
dev.copy(png,'4.3.SO2_Pop.png')
dev.off()
chiplot(SO2, Wind, vlabs=c("SO2", "Wind"))
dev.copy(png,'4.4.SO2_Wind.png')
dev.off()
chiplot(SO2, Precip, vlabs=c("SO2", "Precip"))
dev.copy(png,'4.5.SO2_Precip.png')
dev.off()
chiplot(SO2, Days, vlabs=c("SO2", "Days"))
dev.copy(png,'4.6.SO2_Days.png')
dev.off()

chiplot(Neg.Temp, Manuf, vlabs=c("Neg.Temp", "Manuf"))
dev.copy(png,'4.7.Neg.Temp_Manuf.png')
dev.off()
chiplot(Neg.Temp, Pop, vlabs=c("Neg.Temp", "Pop"))
dev.copy(png,'4.8.Neg.Temp_Pop.png')
dev.off()
chiplot(Neg.Temp, Wind, vlabs=c("Neg.Temp", "Wind"))
dev.copy(png,'4.9.Neg.Temp_Wind.png')
dev.off()
chiplot(Neg.Temp, Precip, vlabs=c("Neg.Temp", "Precip"))
dev.copy(png,'4.10.Neg.Temp_Precip.png')
dev.off()
chiplot(Neg.Temp, Days, vlabs=c("Neg.Temp", "Days"))
dev.copy(png,'4.11.Neg.Temp_Days.png')
```

```
dev.off()

chiplot(Manuf, Pop, vlabs=c("Manuf", "Pop"))
dev.copy(png,'4.12.Manuf_Pop.png')
dev.off()
chiplot(Manuf, Wind, vlabs=c("Manuf", "Wind"))
dev.copy(png,'4.13.Manuf_Wind.png')
dev.off()
chiplot(Manuf, Precip, vlabs=c("Manuf", "Precip"))
dev.copy(png,'4.14.Manuf_Precip.png')
dev.off()
chiplot(Manuf, Days, vlabs=c("Manuf", "Days"))
dev.copy(png,'4.15.Manuf_Days.png')
dev.off()

chiplot(Pop, Wind, vlabs=c("Pop", "Wind"))
dev.copy(png,'4.16.Pop_Wind.png')
dev.off()
chiplot(Pop, Precip, vlabs=c("Pop", "Precip"))
dev.copy(png,'4.17.Pop_Precip.png')
dev.off()
chiplot(Pop, Days, vlabs=c("Pop", "Days"))
dev.copy(png,'4.18.Pop_Days.png')
dev.off()

chiplot(Wind, Precip, vlabs=c("Wind", "Precip"))
dev.copy(png,'4.19.Wind_Precip.png')
dev.off()
chiplot(Wind, Days, vlabs=c("Wind", "Days"))
dev.copy(png,'4.20.Wind_Days.png')
dev.off()

chiplot(Precip, Days, vlabs=c("Precip", "Days"))
dev.copy(png,'4.21.Precip_Days.png')
dev.off()
```

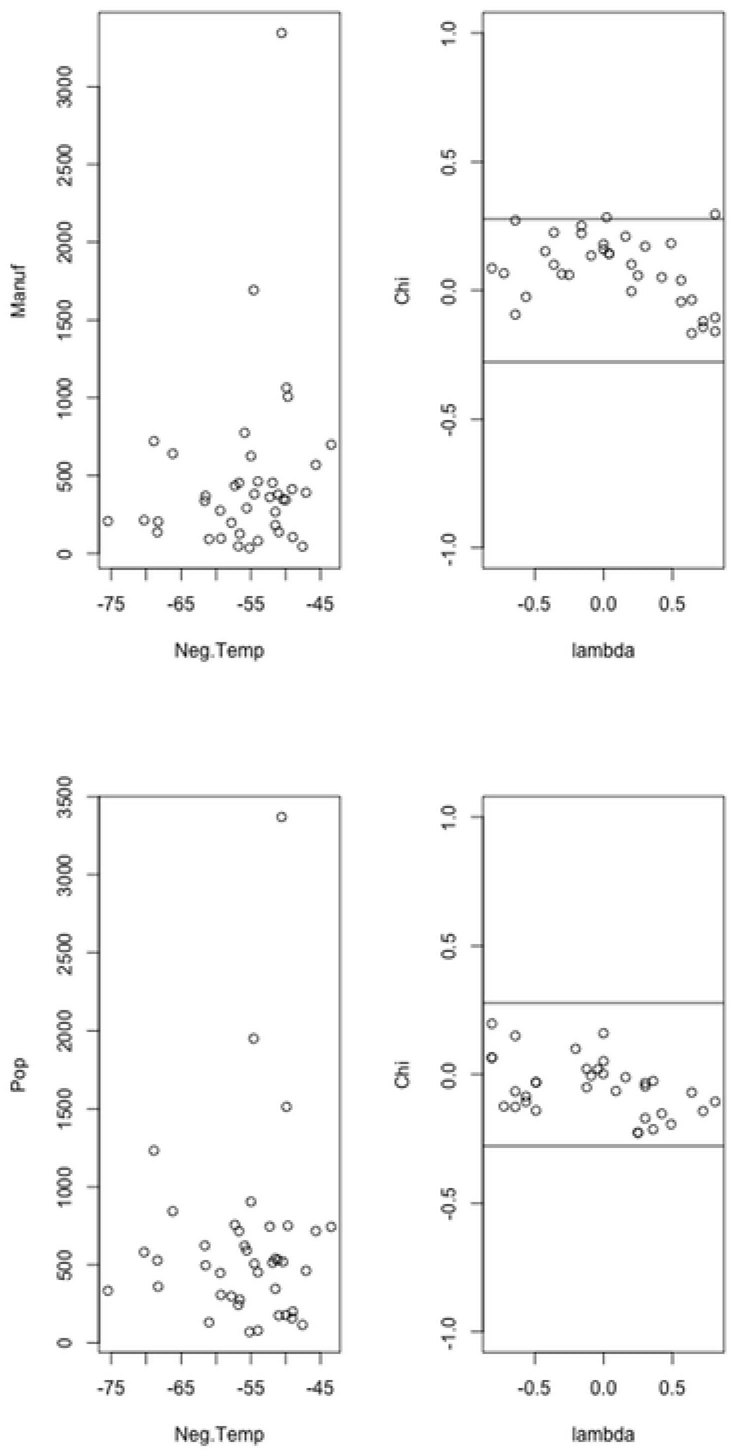

Neg.Temp
SO2
Chi
lambda
Manuf
SO2
Chi
lambda

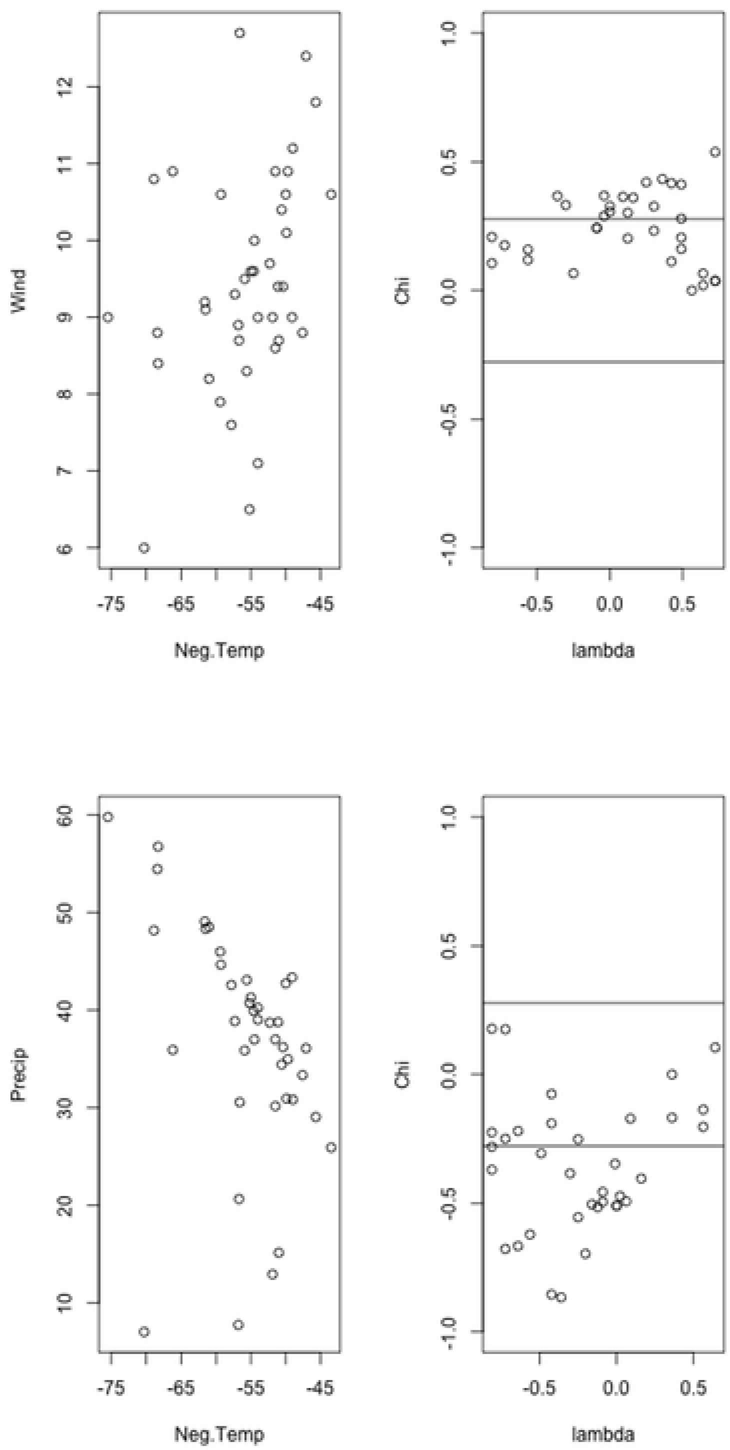


Pop
SO2
Chi
lambda
Wind
SO2
Chi
lambda

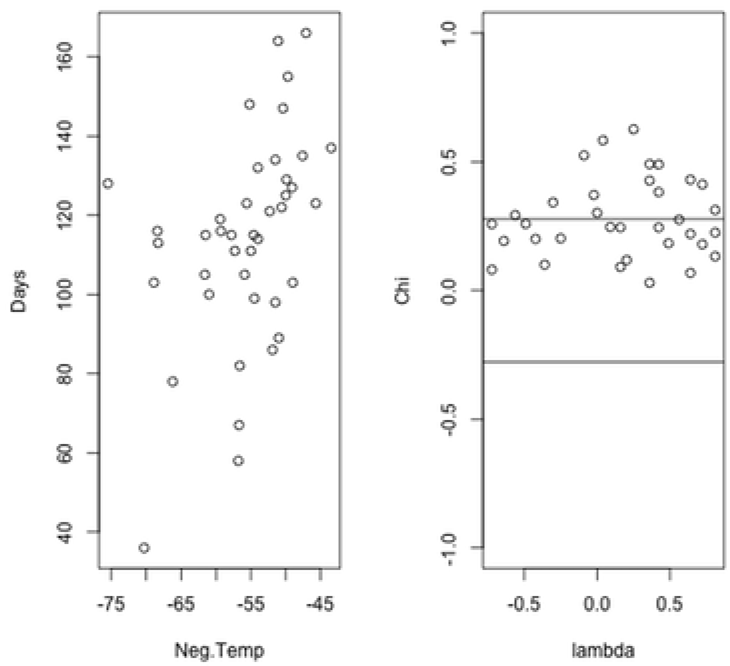


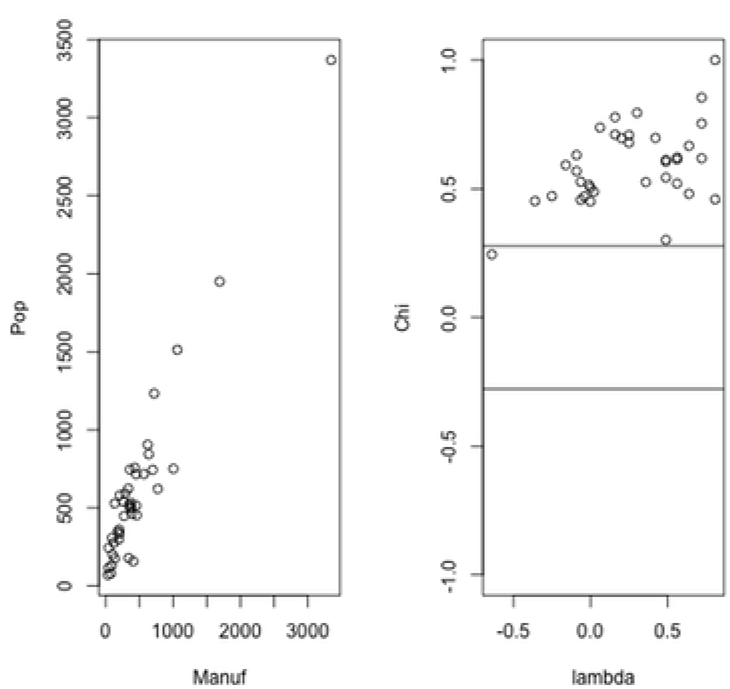
Precip
SO2
Chi
lambda
Days
SO2
Chi
lambda

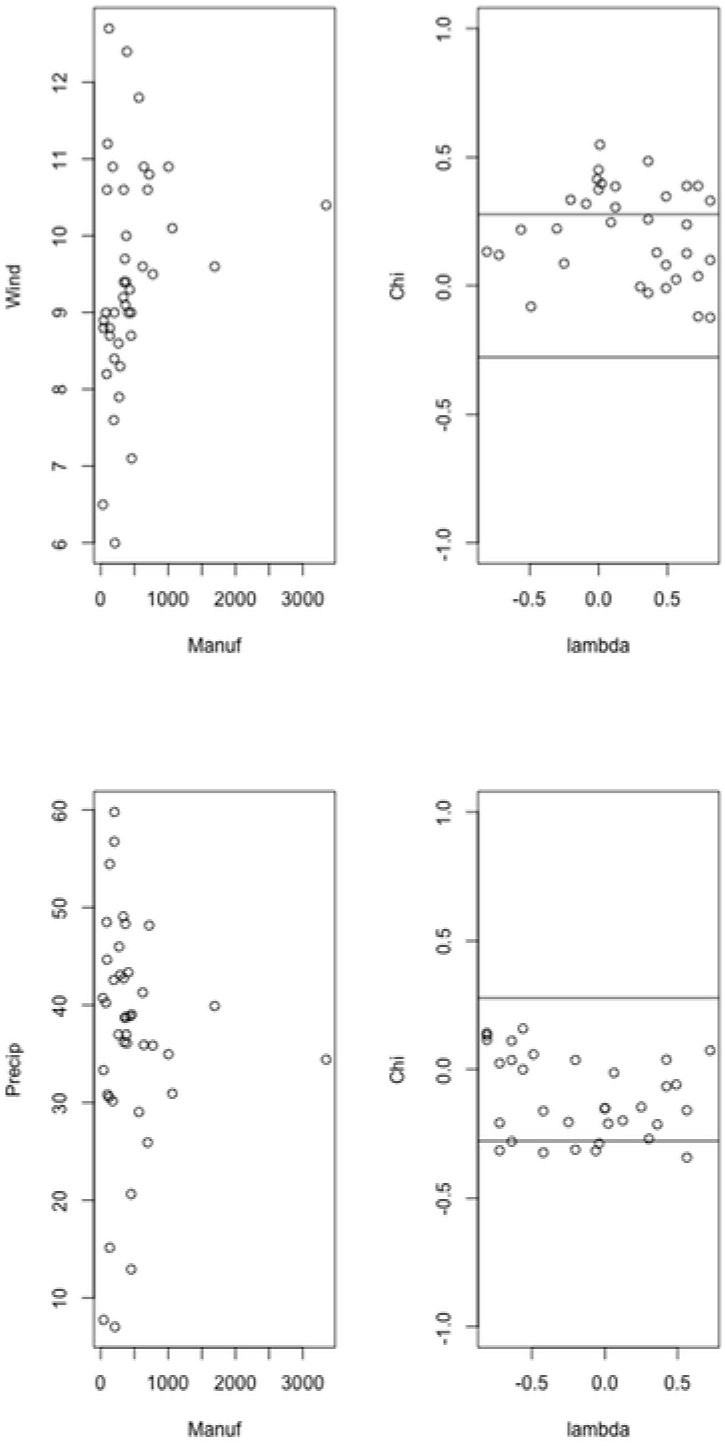

Manuf
0
500
1000
1500
2000
2500
3000
-75
-65
-55
-45
Neg.Temp
Chi
-1.0
-0.5
0.0
0.5
1.0
-0.5
0.0
0.5
lambda
Pop
0
500
1000
1500
2000
2500
3000
3500
-75
-65
-55
-45
Neg.Temp
Chi
-1.0
-0.5
0.0
0.5
1.0
-0.5
0.0
0.5
lambda

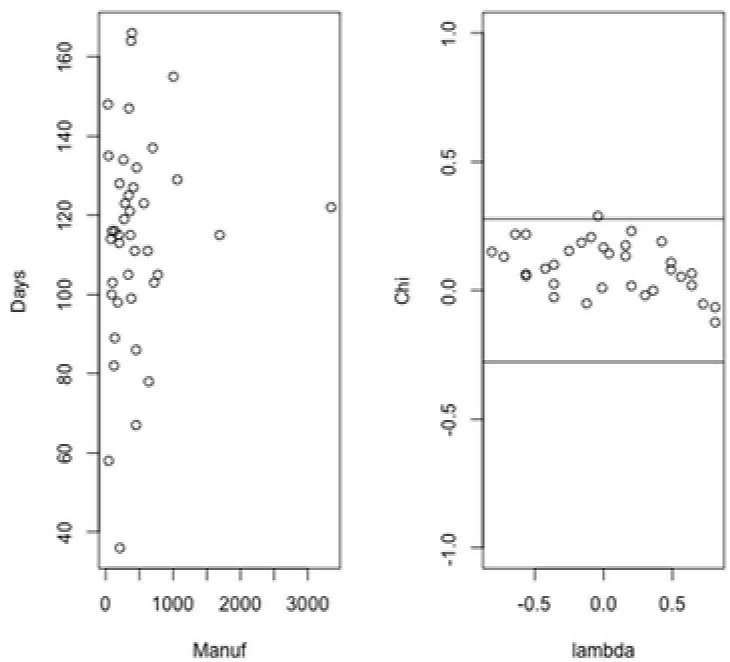


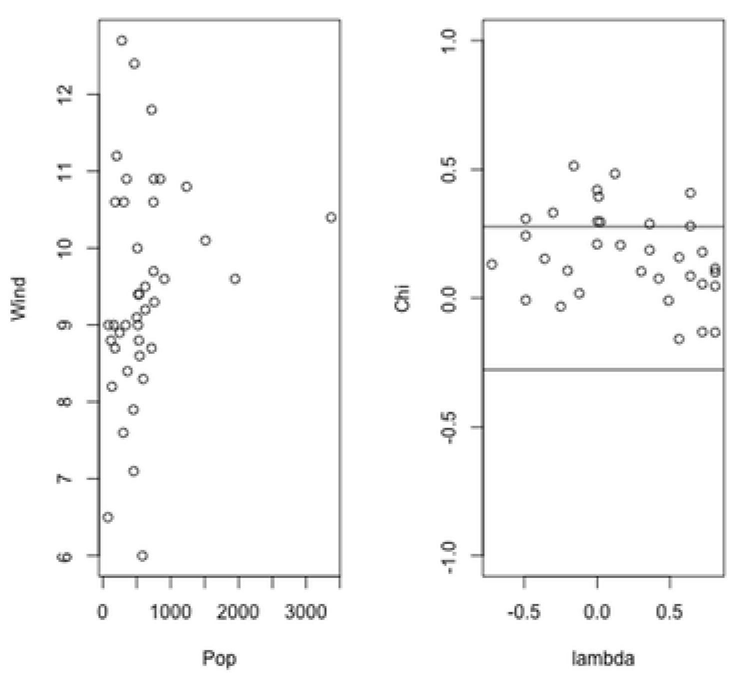
Wind
12
11
10
9
8
7
6
-75
-65
-55
-45
Neg.Temp
Chi
1.0
0.5
0.0
-0.5
-1.0
-0.5
0.0
0.5
lambda
Precip
60
50
40
30
20
10
-75
-65
-55
-45
Neg.Temp
Chi
1.0
0.5
0.0
-0.5
-1.0
-0.5
0.0
0.5
lambda

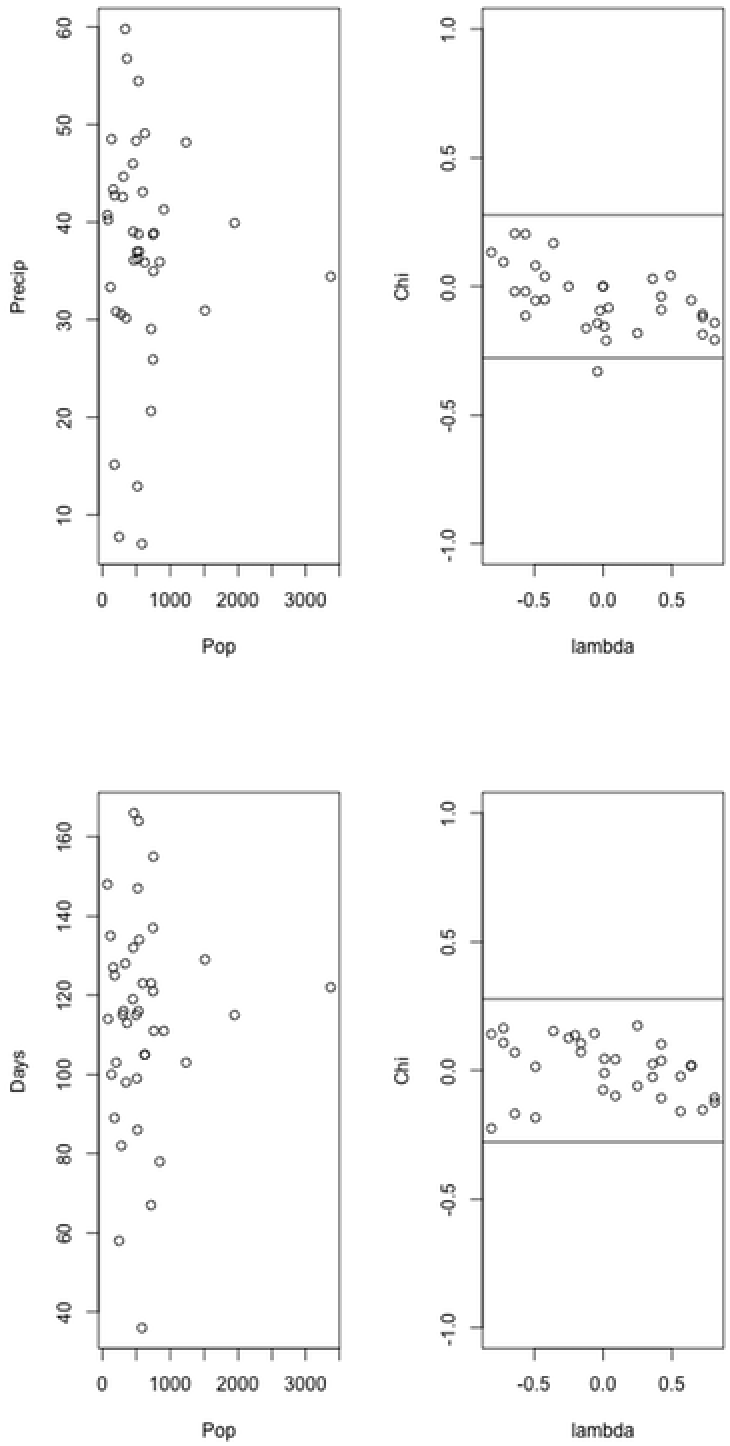

Days
Neg.Temp
-75
-65
-55
-45
40
60
80
100
120
140
160
Chi
lambda
-0.5
0.0
0.5
-1.0
-0.5
0.0
0.5
1.0

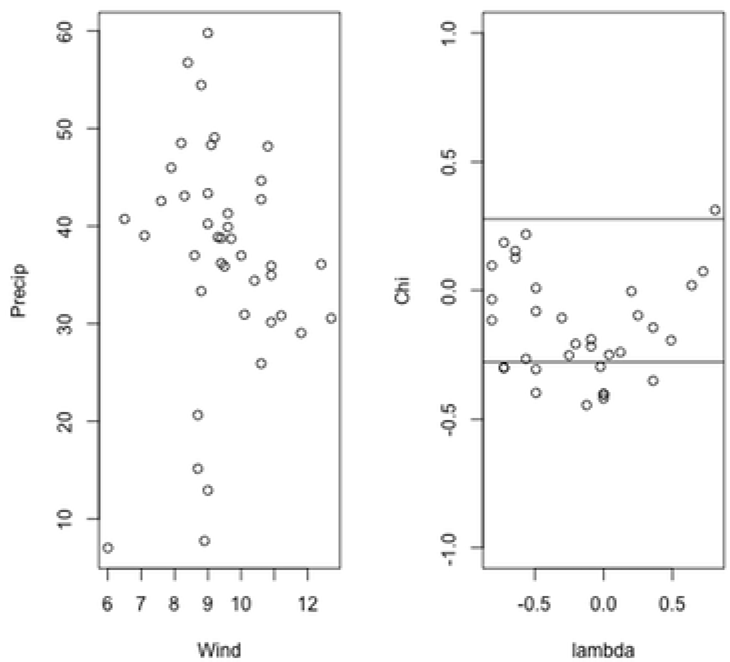

Pop
Manuf
0
1000
2000
3000
0
500
1000
1500
2000
2500
3000
3500
Chi
lambda
-0.5
0.0
0.5
-1.0
-0.5
0.0
0.5
1.0


Wind
Manuf
0
1000
2000
3000
6
7
8
9
10
11
12
Chi
lambda
-0.5
0.0
0.5
-1.0
1.0
Precip
10
20
30
40
50
60

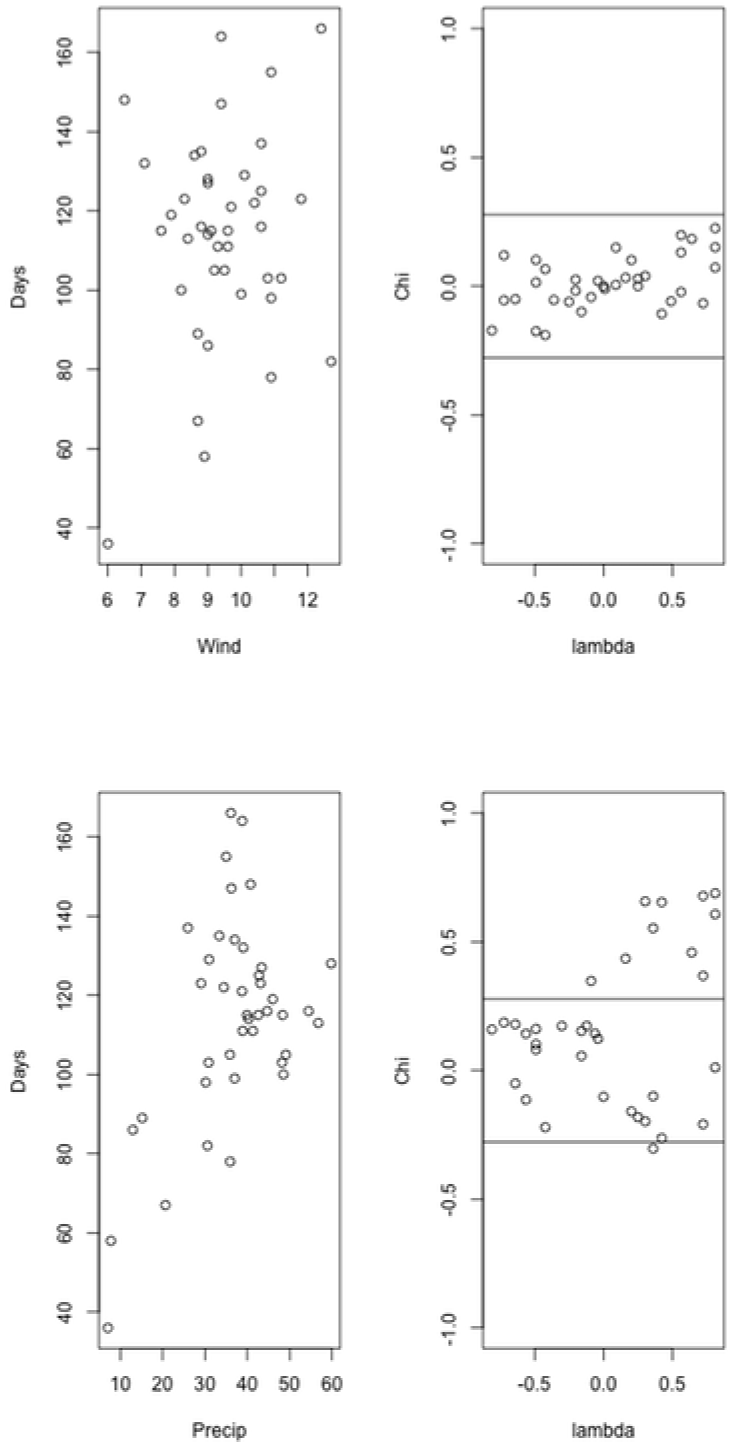

Days
160
140
120
100
80
60
40
0
1000
2000
3000
Manuf
Chi
1.0
0.5
0.0
-0.5
-1.0
-0.5
0.0
0.5
lambda


Wind
12
11
10
9
8
7
6
0
1000
2000
3000
Pop
Chi
1.0
0.5
0.0
-0.5
-1.0
-0.5
0.0
0.5
lambda


Precip
Pop
Chi
lambda
Days
Pop
Chi
lambda



Precip
Wind
Chi
lambda



Days
Wind
Chi
lambda
Days
Precip
Chi
lambda