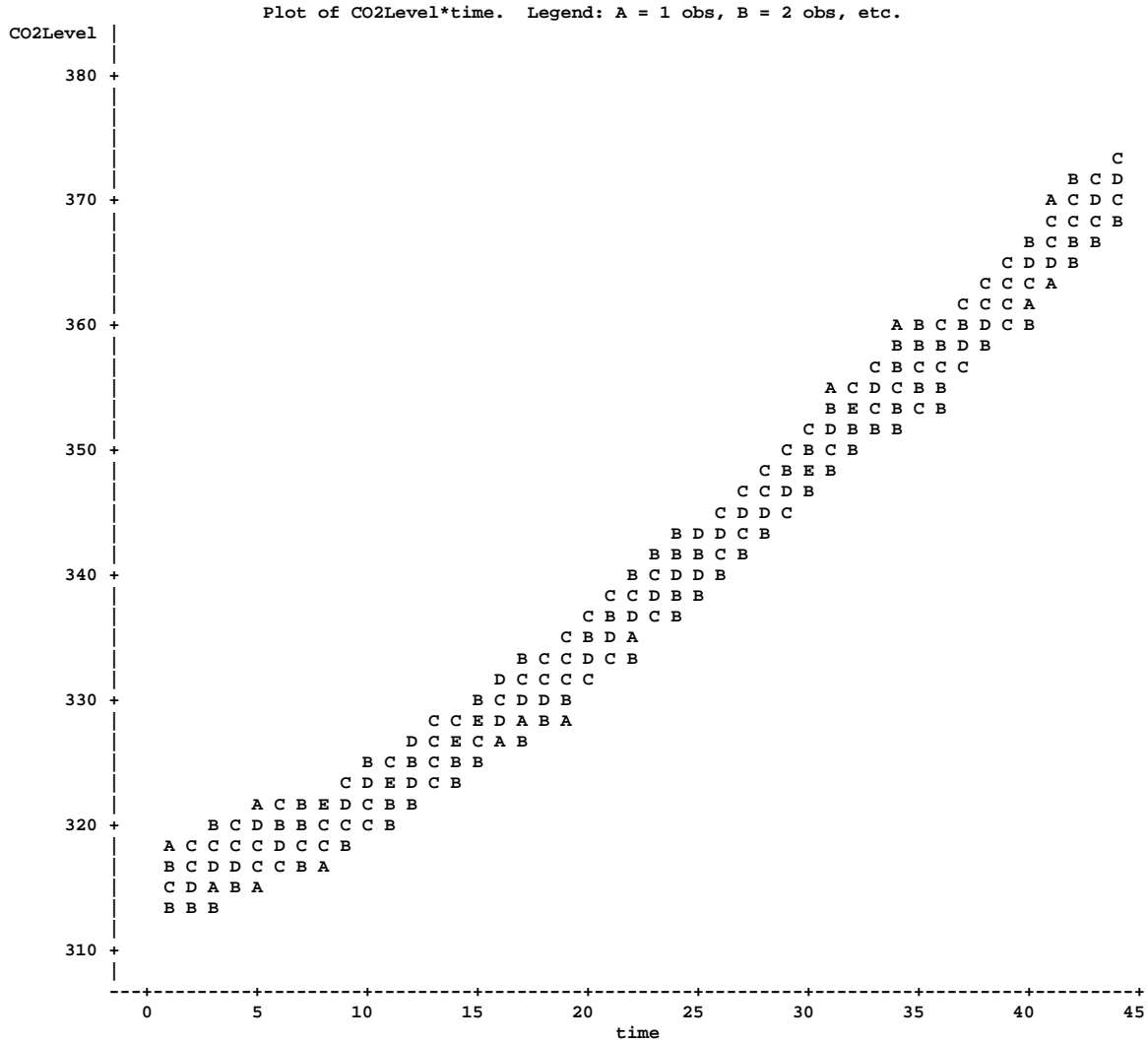


```

1      /*
2      *-----1-----2-----3-----4-----5-----6-----7-----8;
3      DATA SET TITLE: ATMOSPHERIC CO2 CONC - MAUNA LOA OBSERVATORY, HAWAII, 1958-2001.
4      CONTRIBUTORS: C. D. KEELING, T. P. WHORF (AND THE CARBON DIOXIDE RESEARCH
5      GROUP), SCRIPPS INSTITUTION OF OCEANOGRAPHY, UNIVERSITY OF CALIFORNIA,
6      LA JOLLA, CALIFORNIA 92093-0444
7      SCOPE OF THE DATA: THE DATA FILE CONTAINS MONTHLY AND ANNUAL ATMOSPHERIC
8      CO2 CONCENTRATIONS DERIVED FROM THE SCRIPPS INSTITUTION OF
9      OCEANOGRAPHY'S (SIO'S) CONTINUOUS MONITORING PROGRAM AT MAUNA LOA
10     OBSERVATORY, HAWAII. THIS RECORD CONSTITUTES THE LONGEST CONTINUOUS
11     RECORD OF ATMOSPHERIC CO2 CONCENTRATIONS AVAILABLE IN THE WORLD.
12     MONTHLY AND ANNUAL AVERAGE MOLE FRACTIONS OF CO2 IN WATER-VAPOR-FREE AIR
13     ARE GIVEN FROM MARCH 1958 THROUGH DECEMBER 2001, EXCEPT FOR A FEW INTERRUPTIONS.
14     DATA FORMAT: ALL CONC. ARE EXPRESSED IN PARTS PER MILLION BY VOLUME (PPMV) IN
15     THE SIO X99 MOLE FRACTION SCALE. MISSING VALUES ARE REPRESENTED BY -99.99.
16     *-----1-----2-----3-----4-----5-----6-----7-----8;
17     */
18
19     options nocenter nodate nonumber ls=80 ps=256;
20     data maunaloa; length month $ 9;
21         title1 'Trend analysis of carbon dioxide levels';
22     infile 'C:\Geaghan\EXST\EXST7015New\Fall2002\SAS\maunaloa.co2.txt' firstobs=15 obs=58;
23     input @1 Year 4. @5 January 7. @12 February 7. @19 March 7. @26 April 7. @33 May
7. @40
24         June 7. @47 July 7. @54 August 7. @61 September 7. @68 October 7. @75
24         November 7. @82 December 7. @89 Annual 7.;
25     time = year - 1957;
26     CO2Level = January; mo = 1; month = 'January'; output;
27     CO2Level = February; mo = 2; month = 'February'; output;
28     CO2Level = March; mo = 3; month = 'March'; output;
29     CO2Level = April; mo = 4; month = 'April'; output;
30     CO2Level = May; mo = 5; month = 'May'; output;
31     CO2Level = June; mo = 6; month = 'June'; output;
32     CO2Level = July; mo = 7; month = 'July'; output;
33     CO2Level = August; mo = 8; month = 'August'; output;
34     CO2Level = September; mo = 9; month = 'September'; output;
35     CO2Level = October; mo = 10; month = 'October'; output;
36     CO2Level = November; mo = 11; month = 'November'; output;
37     CO2Level = December; mo = 12; month = 'December'; output;
38     drop January February March April May June July August September
39     October November December Annual;
40     run;
NOTE: The infile 'C:\Geaghan\EXST\EXST7015New\Fall2002\SAS\maunaloa.co2.txt' is:
File Name=C:\Geaghan\EXST\EXST7015New\Fall2002\SAS\maunaloa.co2.txt,
RECFM=V,LRECL=256
NOTE: 44 records were read from the infile
'C:\Geaghan\EXST\EXST7015New\Fall2002\SAS\maunaloa.co2.txt'.
The minimum record length was 102.
The maximum record length was 102.
NOTE: The data set WORK.MAUNALOA has 528 observations and 5 variables.
NOTE: DATA statement used:
real time          0.06 seconds
cpu time           0.06 seconds
41
42     data maunaloa; set maunaloa;
43         if co2level lt 0 then co2level = .;
44         loglevel = log(co2level);
45     run;
46
47
48     *proc print noobs; run;
49     options ls=111 ps=56;
50     proc plot data=maunaloa; plot co2level*time; run;
51     options ls=80 ps=256;
NOTE: There were 528 observations read from the data set WORK.MAUNALOA.
NOTE: The PROCEDURE PLOT printed page 1.
NOTE: PROCEDURE PLOT used:
real time          0.05 seconds
cpu time           0.03 seconds

```

Trend analysis of carbon dioxide levels



```

53      proc mixed data=maunaloa; classes month;
54          title2 'Basic Analysis of Covariance using PROC MIXED';
55          model co2level = time month time*month / htype=1 3 DDFM=Satterthwaite;
56          run;
NOTE: 7 observations are not included because of missing values.
NOTE: The PROCEDURE MIXED printed page 2.
NOTE: PROCEDURE MIXED used:
      real time          0.07 seconds
      cpu time           0.07 seconds
    
```

Trend analysis of carbon dioxide levels
Basic Analysis of Covariance using PROC MIXED

The Mixed Procedure

Model Information	
Data Set	WORK.MAUNALOA
Dependent Variable	CO2Level
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Class Level Information	
Class	Levels Values
month	12 April August December February January July June March May November October
September	

Dimensions	
Covariance Parameters	1
Columns in X	26
Columns in Z	0
Subjects	1
Max Obs Per Subject	528
Observations Used	521
Observations Not Used	7
Total Observations	528

Covariance Parameter Estimates	
Cov Parm	Estimate
Residual	3.5033

Fit Statistics	
-2 Res Log Likelihood	2184.8
AIC (smaller is better)	2186.8
AICC (smaller is better)	2186.8
BIC (smaller is better)	2191.0

Type 1 Tests of Fixed Effects				
Effect	Num	Den	F Value	Pr > F
time	1	497	42276.8	<.0001
month	11	497	45.54	<.0001
time*month	11	497	0.26	0.9927

Type 3 Tests of Fixed Effects				
Effect	Num	Den	F Value	Pr > F
time	1	497	42195.7	<.0001
month	11	497	9.51	<.0001
time*month	11	497	0.26	0.9927

```
59      proc glm data=maunaloa; classes month;
60          title2 'Basic Analysis of Covariance using PROC GLM';
61          model co2level = time month time*month / solution;
62      run;
```

NOTE: The PROCEDURE GLM printed pages 3-4.

NOTE: PROCEDURE GLM used:

real time	0.08 seconds
cpu time	0.08 seconds

Trend analysis of carbon dioxide levels
Basic Analysis of Covariance using PROC GLM

The GLM Procedure	
Class Level Information	
Class	Levels Values
month	12 April August December February January July June March May November October
September	
Number of observations	528

NOTE: Due to missing values, only 521 observations can be used in this analysis.

Trend analysis of carbon dioxide levels
Basic Analysis of Covariance using PROC GLM

Dependent Variable: CO2Level

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	149874.8665	6516.2985	1860.02	<.0001
Error	497	1741.1612	3.5033		
Corrected Total	520	151616.0277			

R-Square	Coeff Var	Root MSE	CO2Level Mean
0.988516	0.550729	1.871722	339.8628

Source	DF	Type I SS	Mean Square	F Value	Pr > F
time	1	148110.2034	148110.2034	42276.8	<.0001
month	11	1754.7861	159.5260	45.54	<.0001
time*month	11	9.8771	0.8979	0.26	0.9927

Source	DF	Type III SS	Mean Square	F Value	Pr > F
time	1	147825.9593	147825.9593	42195.7	<.0001
month	11	366.6464	33.3315	9.51	<.0001
time*month	11	9.8771	0.8979	0.26	0.9927

Parameter	Estimate	Standard Error	t Value	Pr > t
Intercept	307.1697146 B	0.57410421	535.04	<.0001
time	1.3144369 B	0.02222108	59.15	<.0001
month April	4.3696829 B	0.82363751	5.31	<.0001
month August	1.5290698 B	0.81190596	1.88	0.0602
month December	1.7211416 B	0.81190596	2.12	0.0345
month February	1.9953236 B	0.84506816	2.36	0.0186
month January	1.4453398 B	0.83122443	1.74	0.0827
month July	3.3254757 B	0.81190596	4.10	<.0001
month June	4.1589625 B	0.83122443	5.00	<.0001
month March	3.1485337 B	0.82363751	3.82	0.0001
month May	4.9943340 B	0.81190596	6.15	<.0001
month November	0.7041332 B	0.81190596	0.87	0.3862
month October	-0.8184642 B	0.83122443	-0.98	0.3253
month September	0.0000000 B	.	.	.
time*month April	0.0302079 B	0.03170608	0.95	0.3412
time*month August	0.0088393 B	0.03142535	0.28	0.7786
time*month December	0.0344038 B	0.03142535	1.09	0.2741
time*month February	0.0369158 B	0.03232065	1.14	0.2539
time*month January	0.0290137 B	0.03198159	0.91	0.3647
time*month July	0.0155849 B	0.03142535	0.50	0.6202
time*month June	0.0365205 B	0.03198159	1.14	0.2540
time*month March	0.0285085 B	0.03170608	0.90	0.3690
time*month May	0.0280599 B	0.03142535	0.89	0.3723
time*month November	0.0242607 B	0.03142535	0.77	0.4405
time*month October	0.0289971 B	0.03198159	0.91	0.3650
time*month September	0.0000000 B	.	.	.

NOTE: The X'X matrix has been found to be singular, and a generalized inverse was used to solve the normal equations. Terms whose estimates are followed by the letter 'B' are not uniquely estimable.

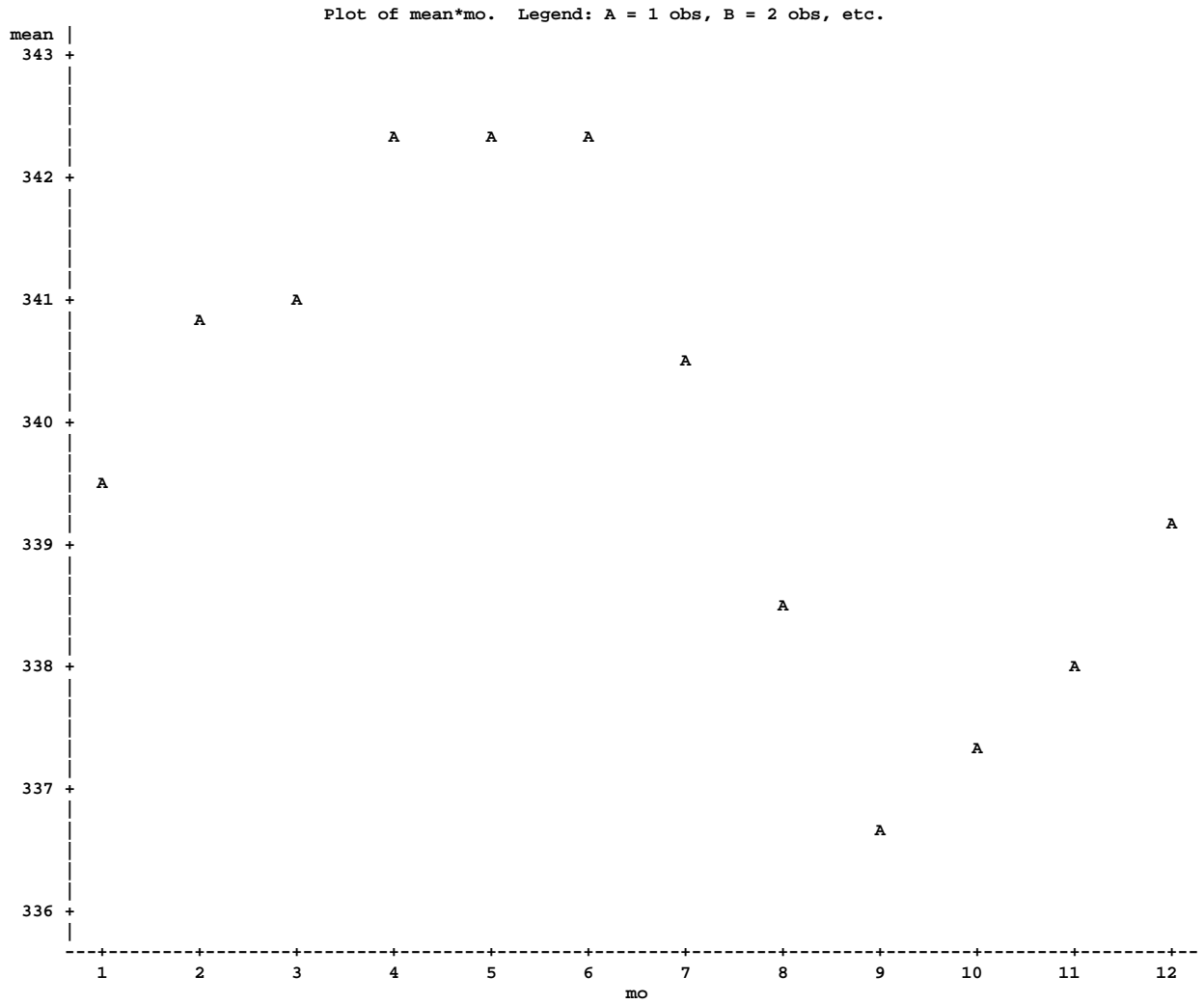
```

64      proc sort data=maunaloa; by mo; run;
NOTE: There were 528 observations read from the data set WORK.MAUNALOA.
NOTE: The data set WORK.MAUNALOA has 528 observations and 6 variables.
NOTE: PROCEDURE SORT used:
      real time          0.04 seconds
      cpu time           0.04 seconds
65      proc means data=maunaloa noprint; by mo;
66          title2 'Calculate and plot means to examine pattern over a year';
67          var co2level; output out=next n=n mean=mean var=var;
68      run;
NOTE: There were 528 observations read from the data set WORK.MAUNALOA.
NOTE: The data set WORK.NEXT has 12 observations and 6 variables.
NOTE: PROCEDURE MEANS used:
      real time          0.05 seconds
      cpu time           0.05 seconds
69      options ls=111 ps=56;

```

```
70      proc plot data=next; plot mean*mo; run;
71      options ls=80 ps=256;
NOTE: There were 12 observations read from the data set WORK.NEXT.
NOTE: The PROCEDURE PLOT printed page 5.
NOTE: PROCEDURE PLOT used:
      real time      0.01 seconds
      cpu time       0.01 seconds
```

Trend analysis of carbon dioxide levels
 Calculate and plot means to examine pattern over a year



```
73      proc mixed data=maunaloa; classes month;
74      title2 'Analysis of Covariance and Response Surface - testing';
75      model co2level = time time*time mo mo*mo mo*mo*mo mo*mo*mo*mo
76      time*mo time*mo*mo time*mo*mo*mo time*mo*mo*mo*mo
77      time*time*mo time*time*mo*mo time*time*mo*mo*mo time*time*mo*mo*mo*mo
78      month month*time / htype=1 3 DDFM=Satterthwaite;
79      run;
NOTE: 7 observations are not included because of missing values.
NOTE: The PROCEDURE MIXED printed page 6.
NOTE: PROCEDURE MIXED used:
      real time      0.07 seconds
      cpu time       0.07 seconds
```

Trend analysis of carbon dioxide levels
 Analysis of Covariance and Response Surface - testing

The Mixed Procedure

Model Information

Data Set	WORK.MAUNALOA
Dependent Variable	CO2Level
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Class Level Information

Class	Levels	Values
month	12	April August December February January July June March May November October September

Dimensions

Covariance Parameters	1
Columns in X	39
Columns in Z	0
Subjects	1
Max Obs Per Subject	528
Observations Used	521
Observations Not Used	7
Total Observations	528

Covariance Parameter Estimates

Cov Parm	Estimate
Residual	0.5614

Fit Statistics

-2 Res Log Likelihood	1415.2
AIC (smaller is better)	1417.2
AICC (smaller is better)	1417.3
BIC (smaller is better)	1421.4

Type 1 Tests of Fixed Effects

Effect	Num	Den	F Value	Pr > F
time	1	491	263837	<.0001
time*time	1	491	2618.04	<.0001
mo	1	491	820.70	<.0001
mo*mo	1	491	359.17	<.0001
mo*mo*mo	1	491	1435.04	<.0001
mo*mo*mo*mo	1	491	326.95	<.0001
time*mo	1	491	0.06	0.8069
time*mo*mo	1	491	1.27	0.2601
time*mo*mo*mo	1	491	8.25	0.0043
time*mo*mo*mo*mo	1	491	0.15	0.7009
time*time*mo	1	491	0.01	0.9111
time*time*mo*mo	1	491	0.80	0.3728
time*time*mo*mo*mo	1	491	0.14	0.7113
time*time*mo*mo*mo*mo	1	491	0.00	0.9468
month	7	491	25.76	<.0001
time*month	7	491	0.31	0.9474

Type 3 Tests of Fixed Effects

Effect	Num	Den	F Value	Pr > F
time	1	491	54.27	<.0001
time*time	1	491	36.19	<.0001
mo	0	.	.	.
mo*mo	0	.	.	.
mo*mo*mo	0	.	.	.
mo*mo*mo*mo	0	.	.	.
time*mo	0	.	.	.
time*mo*mo	0	.	.	.
time*mo*mo*mo	0	.	.	.
time*mo*mo*mo*mo	0	.	.	.
time*time*mo	1	491	0.09	0.7584
time*time*mo*mo	1	491	0.03	0.8697
time*time*mo*mo*mo	1	491	0.01	0.9357
time*time*mo*mo*mo*mo	1	491	0.00	0.9698
month	5	491	4.95	0.0002
time*month	7	491	0.31	0.9474

```

81      proc mixed data=maunaloa; classes month;
82          title2 'Fit of a simplified Response Surface';
83          model co2level = time time*time mo mo*mo mo*mo*mo mo*mo*mo*mo
84              / htype=1 3 DDFM=Satterthwaite outp=ResidDataP solution;
85      run;
NOTE: 7 observations are not included because of missing values.
NOTE: The data set WORK.RESIDDATA has 528 observations and 13 variables.
NOTE: The PROCEDURE MIXED printed page 7.
NOTE: PROCEDURE MIXED used:
      real time          0.16 seconds
      cpu time           0.16 seconds
86      quit;

```

Trend analysis of carbon dioxide levels
Fit of a simplified Response Surface

The Mixed Procedure

Model Information	
Data Set	WORK.MAUNALOA
Dependent Variable	CO2Level
Covariance Structure	Diagonal
Estimation Method	REML
Residual Variance Method	Profile
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Residual

Class Level Information	
Class	Levels Values
month	12 April August December February January July June March May November October September

Dimensions	
Covariance Parameters	1
Columns in X	7
Columns in Z	0
Subjects	1
Max Obs Per Subject	528
Observations Used	521
Observations Not Used	7
Total Observations	528

Covariance Parameter Estimates	
Cov Parm	Estimate
Residual	0.7484

Fit Statistics	
-2 Res Log Likelihood	1391.5
AIC (smaller is better)	1393.5
AICC (smaller is better)	1393.5
BIC (smaller is better)	1397.7

Solution for Fixed Effects					
Effect	Estimate	Standard Error	DF	t Value	Pr > t
Intercept	312.28	0.3637	514	858.72	<.0001
time	0.8051	0.01244	514	64.70	<.0001
time*time	0.01178	0.000266	514	44.25	<.0001
mo	-0.04612	0.3342	514	-0.14	0.8903
mo*mo	0.6626	0.09890	514	6.70	<.0001
mo*mo*mo	-0.1346	0.01121	514	-12.00	<.0001
mo*mo*mo*mo	0.006711	0.000429	514	15.66	<.0001

Type 1 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
time	1	514	197913	<.0001
time*time	1	514	1963.89	<.0001
mo	1	514	615.64	<.0001
mo*mo	1	514	269.43	<.0001
mo*mo*mo	1	514	1076.47	<.0001
mo*mo*mo*mo	1	514	245.26	<.0001

Type 3 Tests of Fixed Effects

Effect	Num	Den	F Value	Pr > F
time	1	514	4186.59	<.0001
time*time	1	514	1958.27	<.0001
mo	1	514	0.02	0.8903
mo*mo	1	514	44.89	<.0001
mo*mo*mo	1	514	144.04	<.0001
mo*mo*mo*mo	1	514	245.26	<.0001

```
88      PROC UNIVARIATE DATA=ResidDataP PLOT NORMAL; VAR resid;
91      RUN;
NOTE: The PROCEDURE UNIVARIATE printed pages 8-9.
NOTE: PROCEDURE UNIVARIATE used:
      real time      3.66 seconds
      cpu time      0.32 seconds
```

Trend analysis of carbon dioxide levels
 Fit of a simplified Response Surface

The UNIVARIATE Procedure
 Variable: Resid

Moments			
N	521	Sum Weights	521
Mean	0	Sum Observations	0
Std Deviation	0.86007223	Variance	0.73972425
Skewness	0.29861691	Kurtosis	-0.1936156
Uncorrected SS	384.65661	Corrected SS	384.65661
Coeff Variation	.	Std Error Mean	0.03768045

Basic Statistical Measures			
Location		Variability	
Mean	0.00000	Std Deviation	0.86007
Median	-0.05525	Variance	0.73972
Mode	.	Range	5.03599
		Interquartile Range	1.22765

Tests for Location: Mu0=0

Test	-Statistic-	-----p Value-----
Student's t	t 0	Pr > t 1.0000
Sign	M -9.5	Pr >= M 0.4304
Signed Rank	S -2031.5	Pr >= S 0.5551

Tests for Normality

Test	--Statistic--	-----p Value-----
Shapiro-Wilk	W 0.992105	Pr < W 0.0073
Kolmogorov-Smirnov	D 0.041427	Pr > D 0.0284
Cramer-von Mises	W-Sq 0.175167	Pr > W-Sq 0.0113
Anderson-Darling	A-Sq 1.092857	Pr > A-Sq 0.0076

Quantiles (Definition 5)

Quantile	Estimate
100% Max	2.7313413
99%	2.0879960
95%	1.5156392
90%	1.1414107
75% Q3	0.6015282
50% Median	-0.0552539
25% Q1	-0.6261222
10%	-1.0483464
5%	-1.2992655
1%	-1.6967417
0% Min	-2.3046472

Extreme Observations

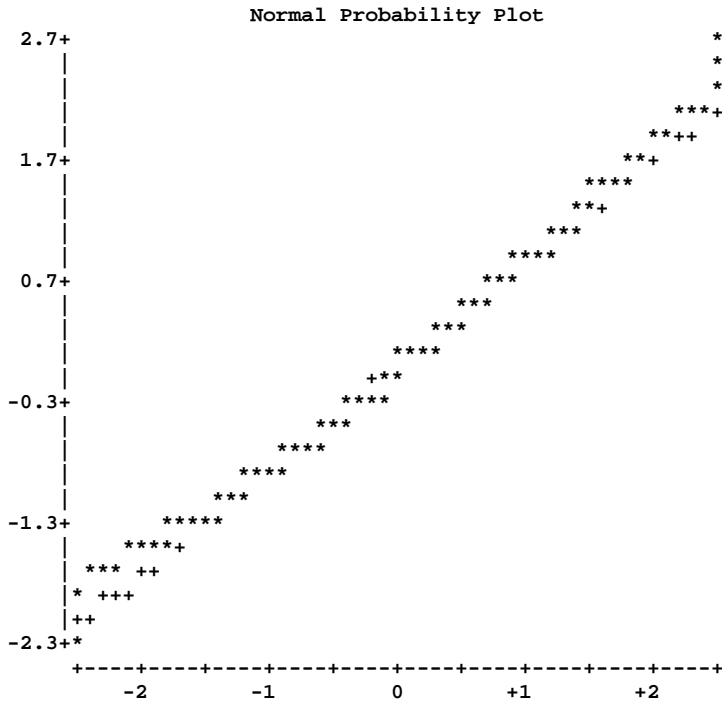
-----Lowest-----		-----Highest-----	
Value	Obs	Value	Obs
-2.30465	392	2.17174	32
-1.99443	388	2.37034	210
-1.98929	103	2.37386	473
-1.84170	396	2.41438	472
-1.69762	371	2.73134	471

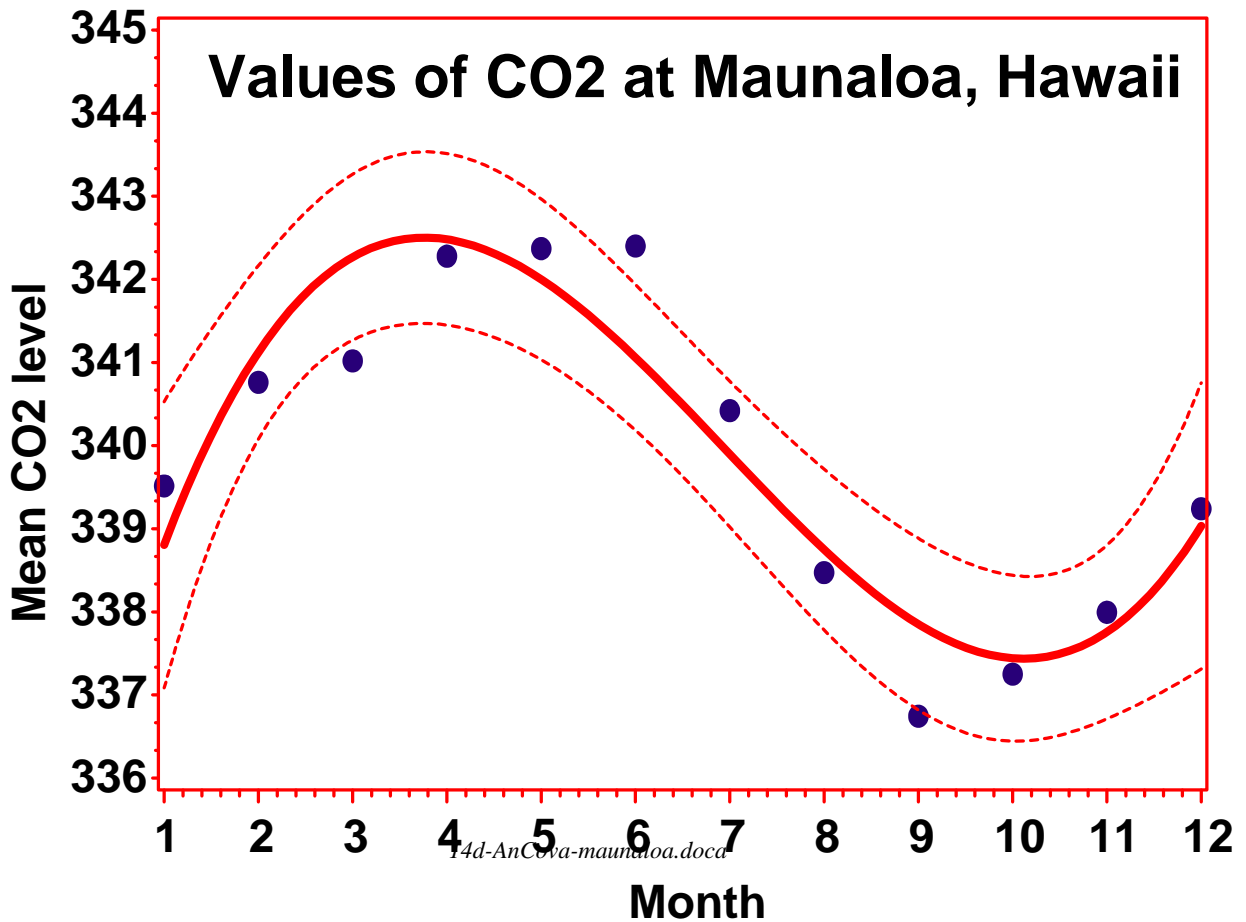
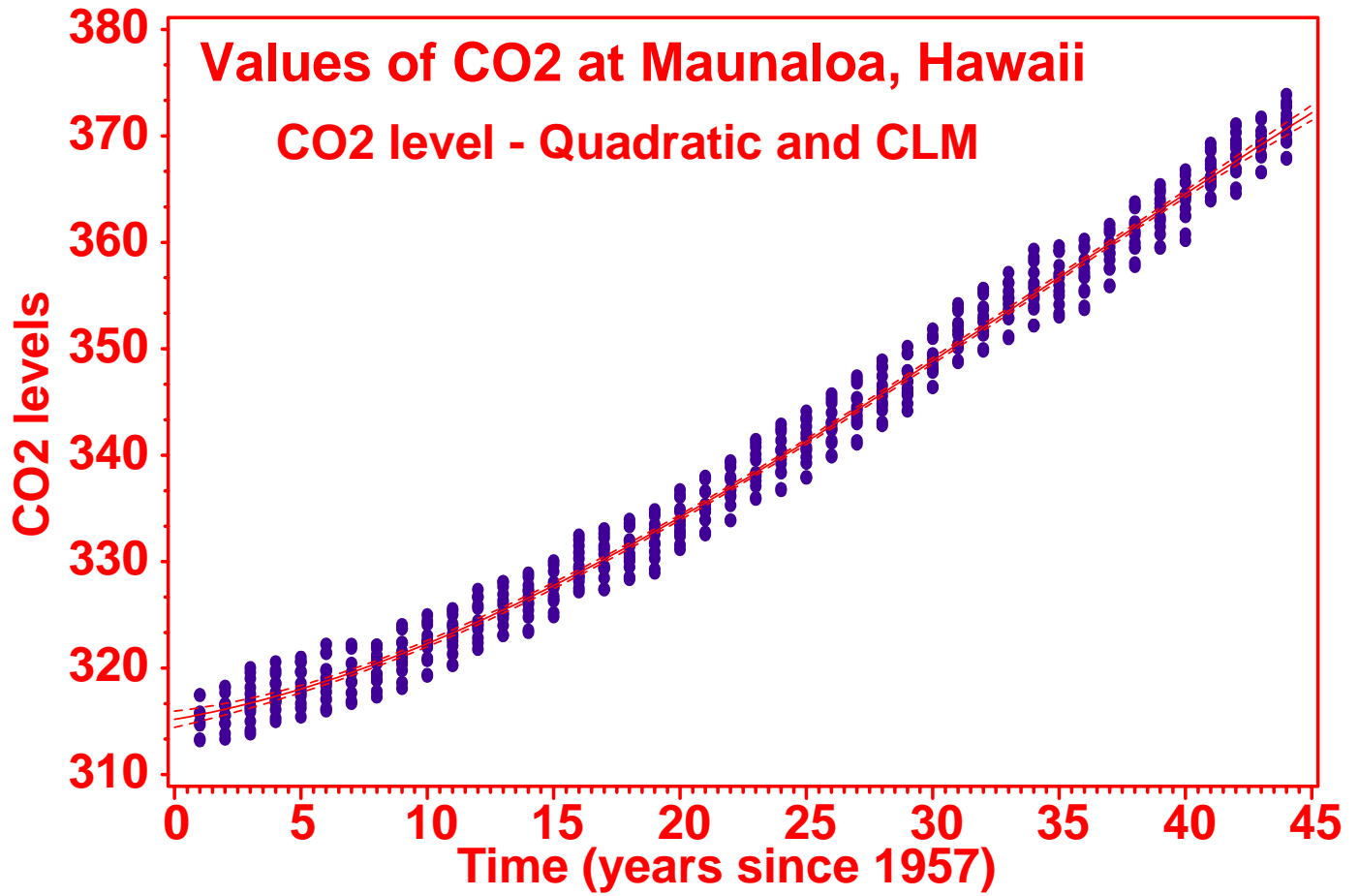
Missing Values

Missing Value	Count	-----Percent Of-----	
		All Obs	Missing Obs
.	7	1.33	100.00

```

Stem Leaf                                     #  Boxplot
26 3                                           1  0
24 1                                           1  |
22 77                                          2  |
20 1397                                       4  |
18 013669                                     6  |
16 301478                                     6  |
14 014602278999                             12 |
12 0027990144589                             13 |
10 00112267891246667999                     20 |
 8 001111233557900223455567888899           30 |
 6 0000111123456667990111111122333345568    37 +-----+
 4 000011233333444566899990000000122233889  40 |
 2 0000124555666677779112222346667789       36 |
 0 11112234555566777701122223455666788999   43 |  +
-0 887666555443332222108877666544333222    37 *-----*
-2 9876666554433222211009988875555544433211000 47 |
-4 8888877776443222211000999888876655443111000 45 |
-6 97776333222110009998766644333322211000   41 +-----+
-8 99777666655531110887776666665322111100    39 |
-10 743211076665554432100                     21 |
-12 4210000887654432100                        20 |
-14 2009432100                                  10 |
-16 007200                                       6  |
-18 994                                           3  |
-20
-22 0                                           1  |
-----+-----+-----+-----+-----+-----+-----+-----+-----+
Multiply Stem.Leaf by 10**-1
    
```





CO2 levels over time

