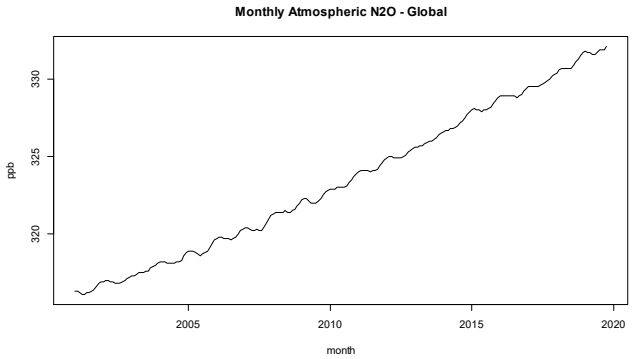
**Department of Statistics**
**STATS 326: Applied Time Series**
**First Semester, 2020**
**Test 2**

## Appendix

Data: These data are monthly measurements of global atmospheric nitrous oxide (N2O) concentration in ppb (parts per billion) from January 2001 to October 2019.

```
> full.N2O.ts = ts(N2O.df$N2O,frequency=12,start=2001)

> full.N2O.ts
       Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
2001 316.3 316.3 316.2 316.1 316.1 316.2 316.2 316.3 316.4 316.6 316.8 316.9
.....
2018 330.4 330.6 330.7 330.7 330.7 330.7 330.7 330.9 331.1 331.3 331.5 331.7
2019 331.8 331.7 331.7 331.6 331.6 331.7 331.9 331.9 331.9 332.1

> plot(full.N2O.ts,main="Monthly Atmospheric N2O - Global",xlab="month",
  ylab="ppb")
```



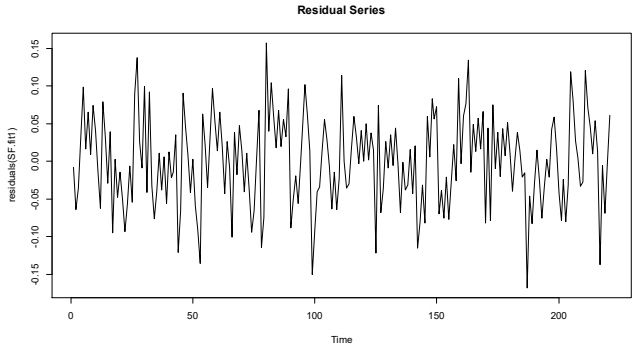

In the following models the observations from July to October 2019 have been dropped from the data.

```
> red.N2O.ts = ts(full.N2O.ts[1:222],frequency=12,start=2001)
> red.N2O.ts
       Jan   Feb   Mar   Apr   May   Jun   Jul   Aug   Sep   Oct   Nov   Dec
2001 316.3 316.3 316.2 316.1 316.1 316.2 316.2 316.3 316.4 316.6 316.8 316.9
.....
2018 330.4 330.6 330.7 330.7 330.7 330.7 330.7 330.9 331.1 331.3 331.5 331.7
2019 331.8 331.7 331.7 331.6 331.6 331.7

> actual = full.N2O.ts[223:226]
> names(actual) = c("2019.7","2019.8","2019.9","2019.10")
> actual
 2019.7  2019.8  2019.9 2019.10
  331.9   331.9   331.9   332.1
```

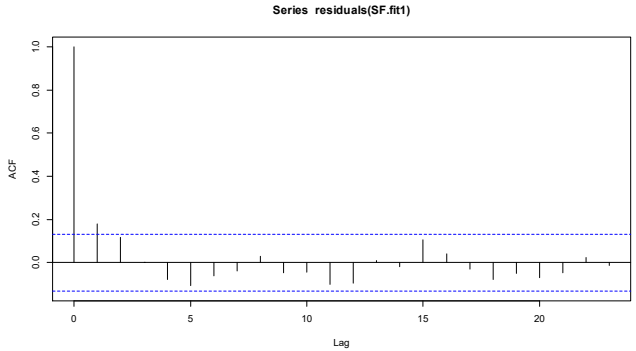


**Seasonal Factor Model:**

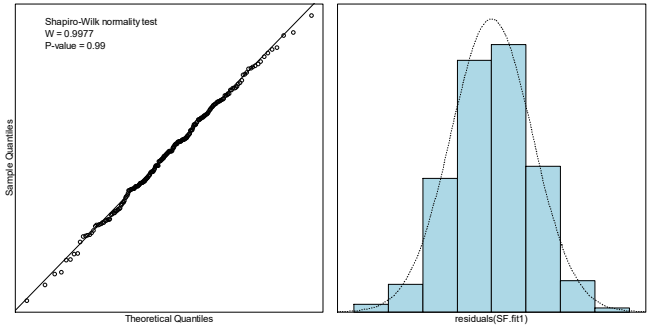
```
> red.Month = factor(c(rep(1:12,18),(1:6)))
> red.Time.break
  [1]   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
.....
 [73]   0   0   0   0   0   0   0   0   1   2   3   4   5   6   7   8   9  10
 [91]  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28
.....
[199] 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136
[217] 137 138 139 140 141 142

> SF.fit1 = lm(red.N2O.ts[-1]~red.Time[-1]+red.Time.break[-1]+
  red.Month[-1]+red.N2O.ts[-222])

> plot.ts(residuals(SF.fit1),main="Residual Series")
```




```
> acf(residuals(SF.fit1))
```



```
> normcheck(residuals(SF.fit1),shapiro.wilk=T)
```




```
> summary(SF.fit1)

Call:
lm(formula = red.N2O.ts[-1] ~ red.Time[-1] + red.Time.break[-1] +
    red.Month[-1] + red.N2O.ts[-222])

Residuals:
      Min        1Q    Median        3Q       Max
-0.167583 -0.038330  0.002484  0.040839  0.157035

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)        31.7838298  9.6267312   3.302 0.001133 **
red.Time[-1]        0.0061339  0.0017666   3.472 0.000629 ***
red.Time.break[-1]  0.0018856  0.0007203   2.618 0.009512 **
red.Month[-1]2     -0.0477687  0.0201205  -2.374 0.018509 *
red.Month[-1]3     -0.0977085  0.0200928  -4.863 2.29e-06 ***
red.Month[-1]4     -0.1418753  0.0201691  -7.034 2.90e-11 ***
red.Month[-1]5     -0.1265814  0.0207233  -6.108 4.95e-09 ***
red.Month[-1]6     -0.0981203  0.0214705  -4.570 8.40e-06 ***
red.Month[-1]7     -0.1121256  0.0222803  -5.032 1.05e-06 ***
red.Month[-1]8     -0.0677393  0.0229982  -2.945 0.003596 **
red.Month[-1]9     -0.0073290  0.0230725  -0.318 0.751071
red.Month[-1]10     0.0314360  0.0223212   1.408 0.160535
red.Month[-1]11     0.0791016  0.0213494   3.705 0.000271 ***
red.Month[-1]12     0.0473364  0.0205107   2.308 0.021998 *
red.N2O.ts[-222]    0.8996494  0.0304633  29.532  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.06106 on 206 degrees of freedom
Multiple R-squared:  0.9998,    Adjusted R-squared:  0.9998
F-statistic: 9.257e+04 on 14 and 206 DF,  p-value: < 2.2e-16

> SF.pred
  2019.7   2019.8   2019.9  2019.10
******** ******** 331.9300 332.0974

> actual
 2019.7  2019.8  2019.9 2019.10
  331.9   331.9   331.9   332.1
```



**Full Harmonic Model:**

```
> summary(FH.fit1)

Residuals:
      Min        1Q    Median        3Q       Max
-0.167583 -0.038330  0.002484  0.040839  0.157035

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)        31.7387152  9.6215693   3.299 0.001144 **
red.Time[-1]        0.0061339  0.0017666   3.472 0.000629 ***
red.Time.break[-1]  0.0018856  0.0007203   2.618 0.009512 **
c1[-1]              0.0862213  0.0062645  13.763  < 2e-16 ***
s1[-1]             -0.0449925  0.0080019  -5.623 6.07e-08 ***
c2[-1]              0.0145707  0.0058052   2.510 0.012845 *
s2[-1]             -0.0100624  0.0058435  -1.722 0.086575 .
c3[-1]             -0.0079709  0.0057985  -1.375 0.170738
s3[-1]             -0.0005296  0.0058253  -0.091 0.927643
c4[-1]              0.0061592  0.0058039   1.061 0.289839
s4[-1]             -0.0085992  0.0058195  -1.478 0.141024
c5[-1]             -0.0055221  0.0058179  -0.949 0.343650
s5[-1]             -0.0007269  0.0058040  -0.125 0.900461
c6[-1]             -0.0010074  0.0041088  -0.245 0.806564
red.N2O.ts[-222]    0.8996494  0.0304633  29.532  < 2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.06106 on 206 degrees of freedom
Multiple R-squared:  0.9998,    Adjusted R-squared:  0.9998
F-statistic: 9.257e+04 on 14 and 206 DF,  p-value: < 2.2e-16
```

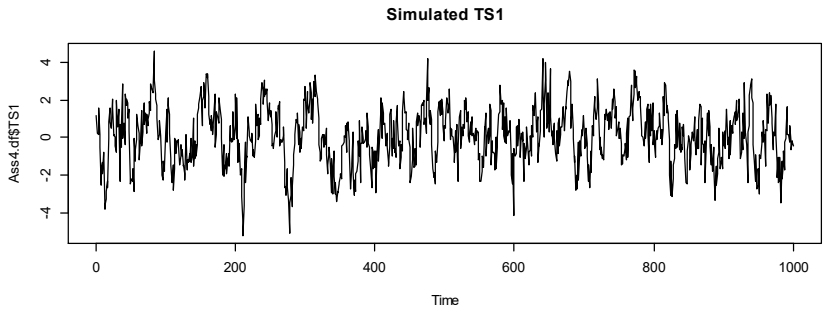
**Reduced Harmonic Models:**

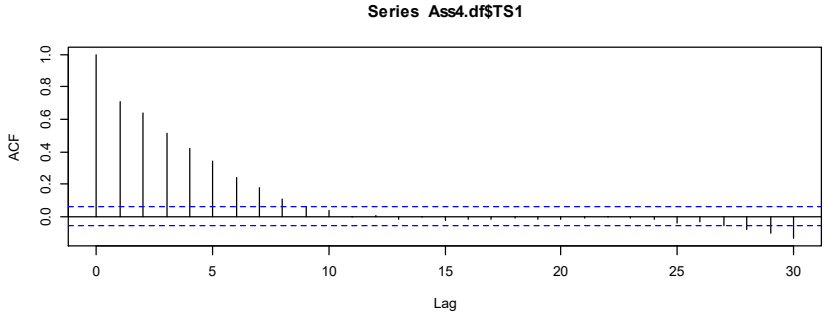
| Month<br>Model | July 2019 | Aug 2019 | Sept 2019 | Oct 2019 | | RMSEP |
|---|---|---|---|---|---|---|
| Sig Pairs | 331.7367 | 331.8111 | 331.9363 | 332.1100 | | 0.09485 |
| Sig Harmonics | 331.7451 | 331.8269 | 331.9502 | 332.1137 | | 0.08951 |

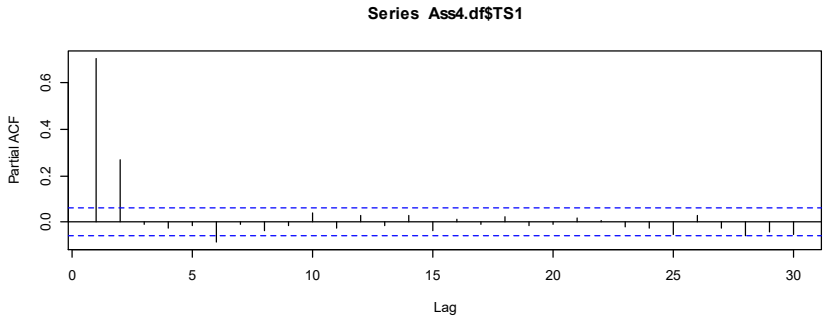
**Cosine Model:**

```
Residuals:
     Min       1Q   Median       3Q      Max
-0.19013 -0.04591  0.00336  0.04122  0.14867

Residual standard error: 0.06188 on 216 degrees of freedom
Multiple R-squared:  0.9998,    Adjusted R-squared:  0.9998
F-statistic: 3.154e+05 on 4 and 216 DF,  p-value: < 2.2e-16

> Cosine.pred
  2019.7   2019.8   2019.9  2019.10
331.7417 331.8356 331.9767 332.1477

> Cosine.RMSEP
[1] 0.09662663
```

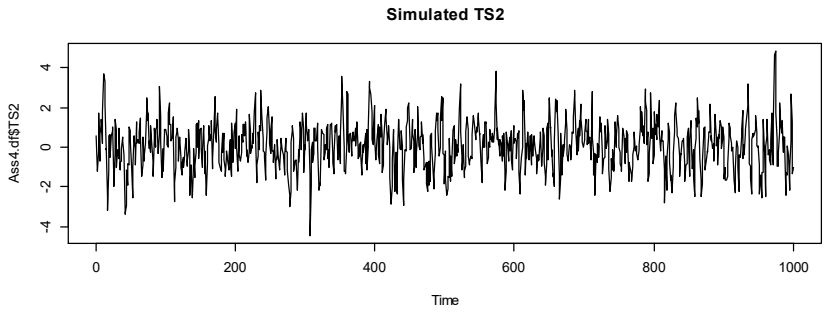
**Simulated Stationary Time Series:**

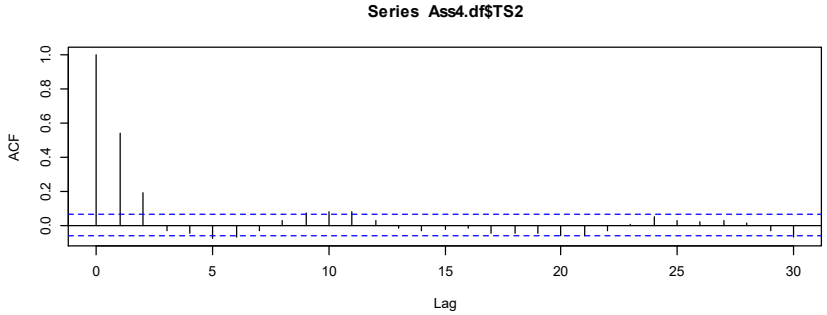


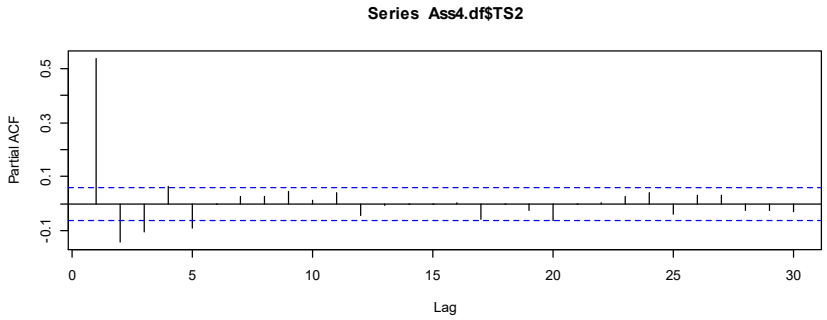



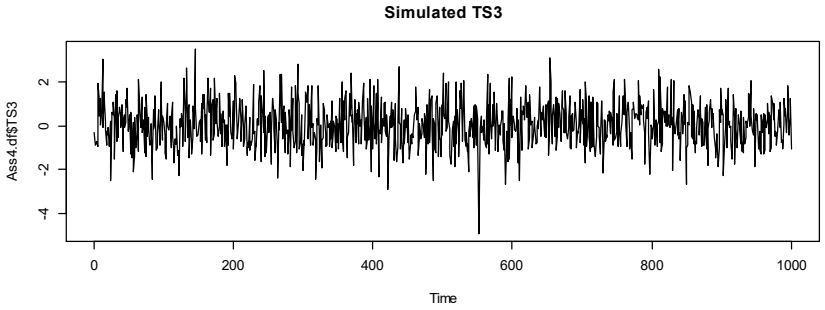



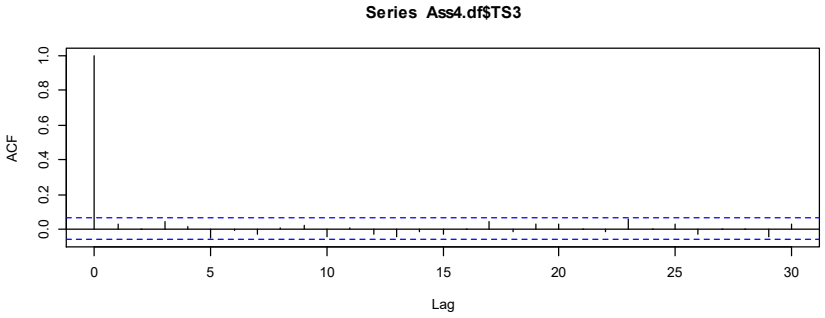


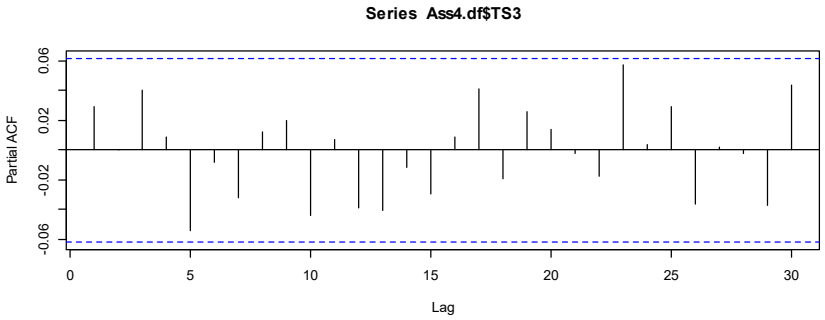



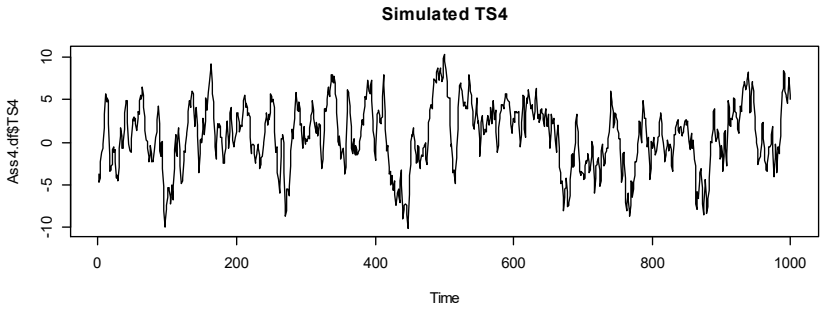



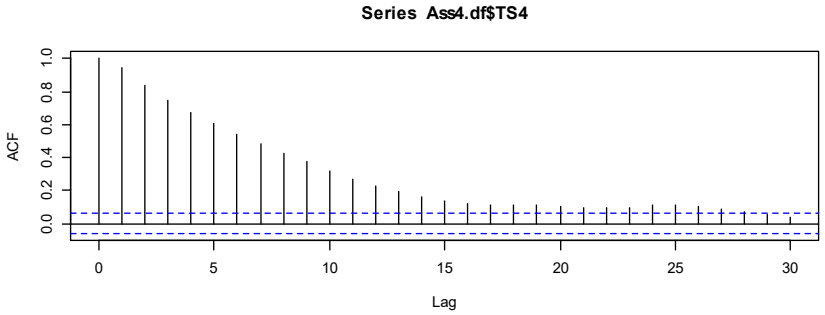

Simulated TS3
Ass4.df$TS3
Time

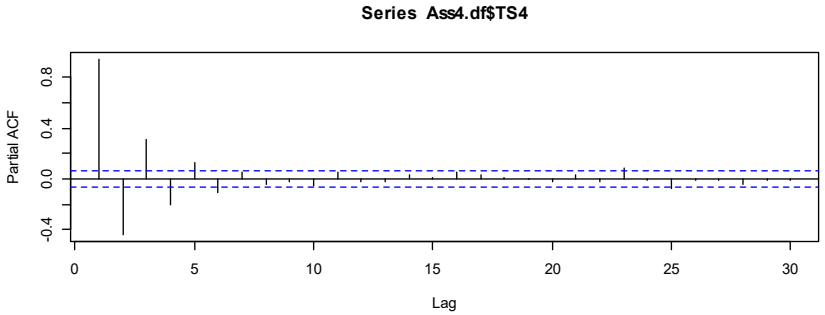

Series Ass4.df$TS3
ACF
Lag


Series Ass4.df$TS3
Partial ACF
Lag




Simulated TS4
Ass4.df$TS4
Time


Series Ass4.df$TS4
ACF
Lag


Series Ass4.df$TS4
Partial ACF
Lag