**Department of Statistics**

**STATS 326: Applied Time Series**

**First Semester, 2020**

**THT1**

**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

**Holt-Winters Model:**

> HW.fit = HoltWinters(red.N2O.ts)

> plot(HW.fit)



> HW.fit

Holt-Winters exponential smoothing with trend and additive seasonal component.

Call:

HoltWinters(x = red.N2O.ts)

Smoothing parameters:

alpha: 0.9029406

beta : 0.01977729

gamma: 1

Coefficients:

[,1]

a 331.7998

b 0.0787

s1 -0.1766

s2 -0.1898

s3 -0.1403

s4 -0.0377

s5 0.1078

s6 0.2053

s7 0.2211

s8 0.1832

s9 0.1209

s10 0.0192

s11 -0.0596

s12 -0.0998

> HW.RMSEP

[1] 0.1197699

**Moving Average Seasonally Adjusted Model:**

> MA.Global = decompose(red.N2O.ts)

> MA.Global$figure

[1] 0.19068968 0.17818968 0.11225831 0.01078772 -0.07303581 -0.12769267

[7] -0.18337078 -0.18823189 -0.13198189 -0.04263004 0.08561070 0.16940700

> MA.red.N2O.ts = red.N2O.ts-MA.Global$seasonal

> plot(MA.red.N2O.ts,main="MA Seasonally Adjusted Global N2O",xlab="month",ylab="ppb")



> MA.fit1 = lm(MA.red.N2O.ts~red.Time)

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

> abline(v=80,lty=2)



> red.Time.break = c(rep(0,79),red.Time[80:222]-red.Time[80])

> 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

> MA.fit2 = lm(MA.red.N2O.ts~red.Time+red.Time.break)

The model MA.fit2 showed autocorrelation in the acf of the Residual Series.

> MA.fit3 = lm(MA.red.N2O.ts[-1]~red.Time[-1]+red.Time.break[-1]+ MA.red.N2O.ts[-222])

> plot.ts(residuals(MA.fit3),main="Residual Series")



> acf(residuals(MA.fit3))



> summary(MA.fit3)

Residuals:

Min 1Q Median 3Q Max

-0.166838 -0.040228 0.000902 0.040731 0.157233

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 3.204e+01 9.399e+00 3.409 0.000777 \*\*\*

red.Time[-1] 6.196e-03 1.726e-03 3.590 0.000408 \*\*\*

red.Time.break[-1] 1.899e-03 7.037e-04 2.698 0.007526 \*\*

MA.red.N2O.ts[-222] 8.987e-01 2.976e-02 30.199 < 2e-16 \*\*\*

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

Residual standard error: 0.05969 on 217 degrees of freedom

Multiple R-squared: 0.9998, Adjusted R-squared: 0.9998

F-statistic: 4.512e+05 on 3 and 217 DF, p-value: < 2.2e-16

> MA.pred

2019.7 2019.8 2019.9 2019.10

331.7213 \*\*\*\*\*\*\*\* 331.9275 \*\*\*\*\*\*\*\*