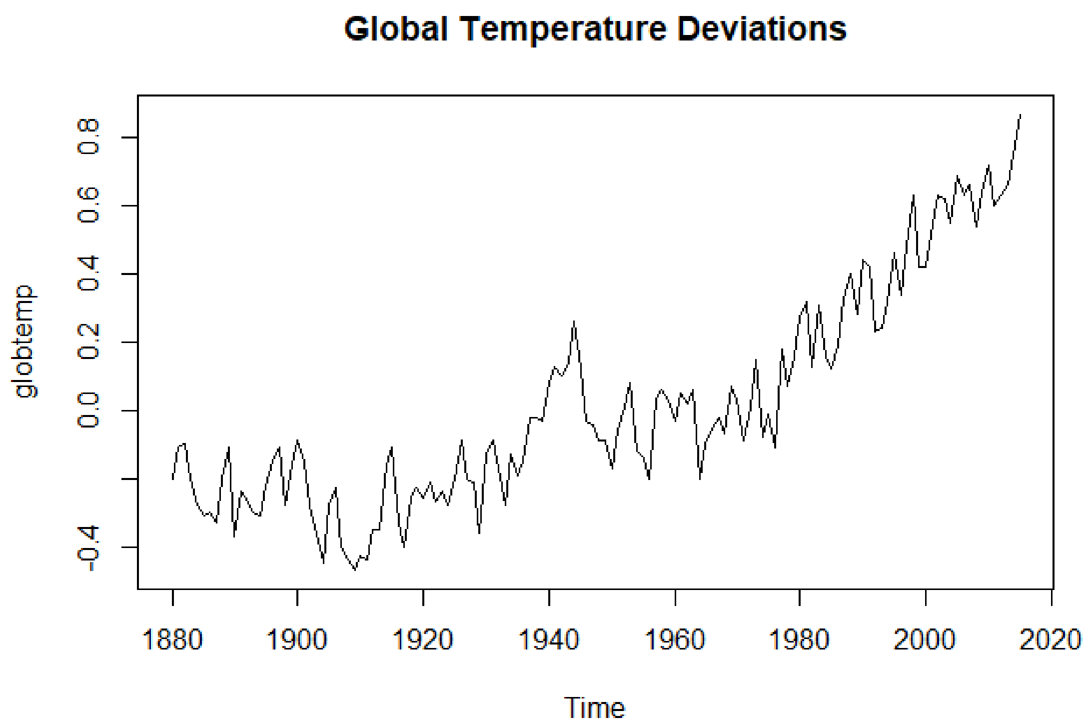
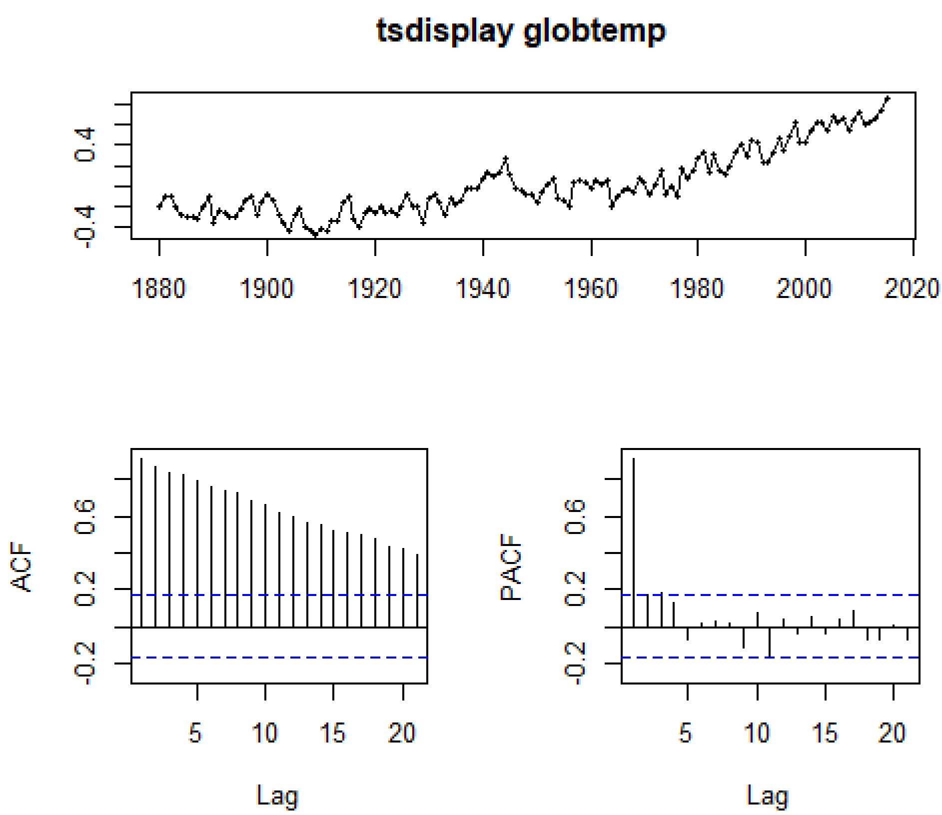
```
> library(astsa)
> require(astsa)
> data(globtemp)# Global mean land-ocean temperature deviations measured in degrees centi
grade, for the years 1880-2015
> class(globtemp)
[1] "ts"

> head(globtemp, 10)
Time Series:
Start = 1880
End = 1889
Frequency = 1
 [1] -0.20 -0.11 -0.10 -0.20 -0.28 -0.31 -0.30 -0.33 -0.20 -0.11

> tail(globtemp, 10)
Time Series:
Start = 2006
End = 2015
Frequency = 1
 [1] 0.63 0.66 0.54 0.64 0.72 0.60 0.63 0.66 0.75 0.87

> plot(globtemp, main = "Global Temperature Deviations", type= "l")
```

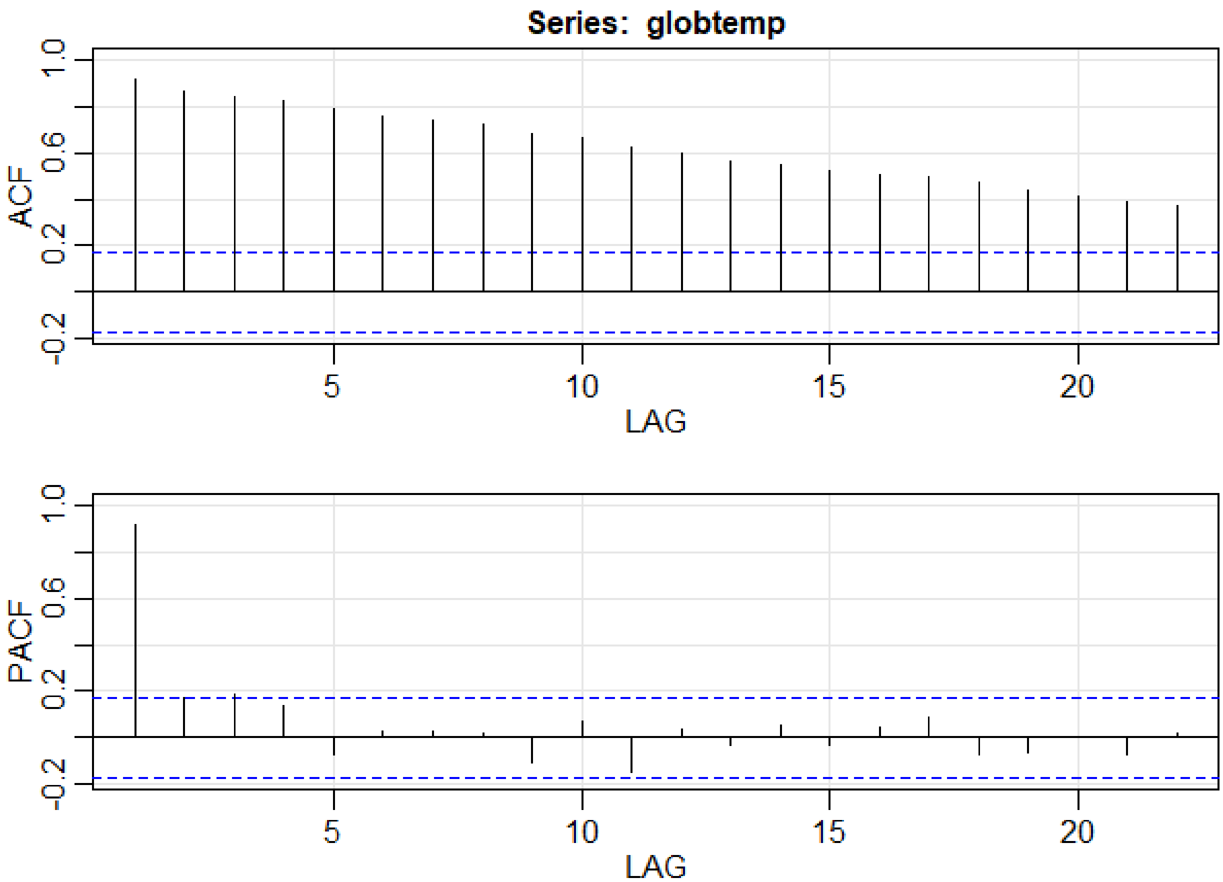



```
> install.packages("forecast")
> require(forecast)
> tsdisplay(globtemp, main="tsdisplay globtemp")
```

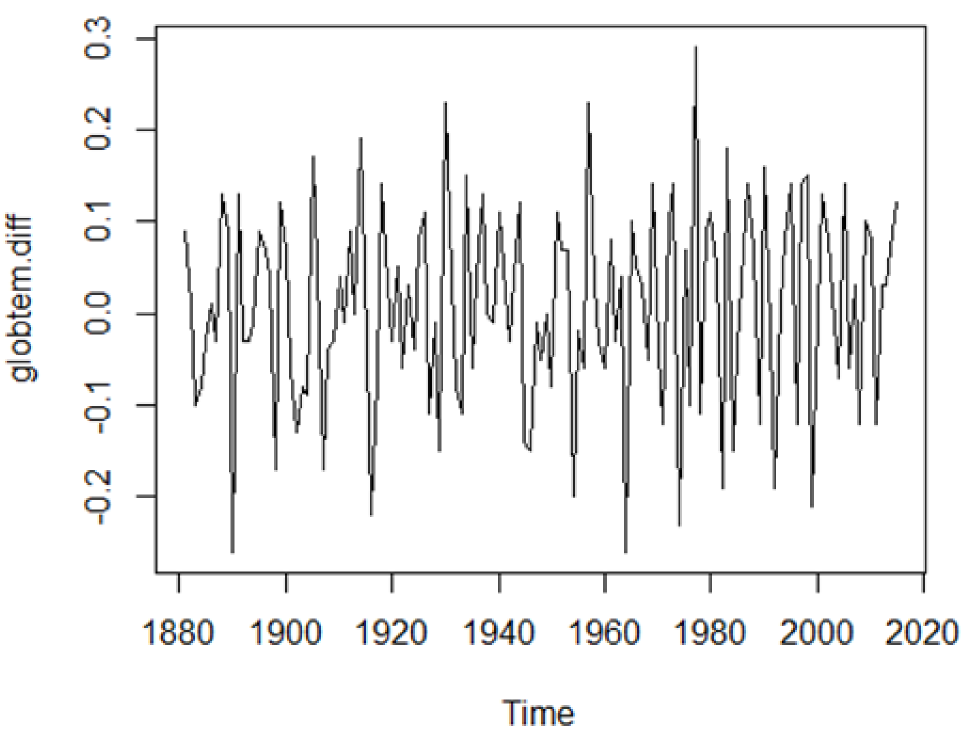



```
> globtemp.stl = stl(globtemp, s.window="periodic")# stl Decomposes a time series into se
asonal, trend and irregular components using loess.

Error in stl(globtemp, s.window = "periodic") :
  series is not periodic or has less than two periods
#the error is due to its lack of seasonality.
> globtemp.reg<-lm(globtemp~time(globtemp)) # create a linear model in order to test hete
roscedasticity.
> install.packages("lmtest")
> require(lmtest)
> bptest(globtemp.reg)

        studentized Breusch-Pagan test

data:  globtemp.reg
BP = 0.74514, df = 1, p-value = 0.388
#null hypothesis that the variance of the residuals is constant. Therefore, we fail to re
ject null.



> install.packages("tseries")
> require(tseries)
> kpss.test(globtemp) # small p-values suggest that the series is not stationary and a di
fferencing is required

        KPSS Test for Level Stationarity

data:  globtemp
KPSS Level = 3.7573, Truncation lag parameter = 2, p-value = 0.01
```

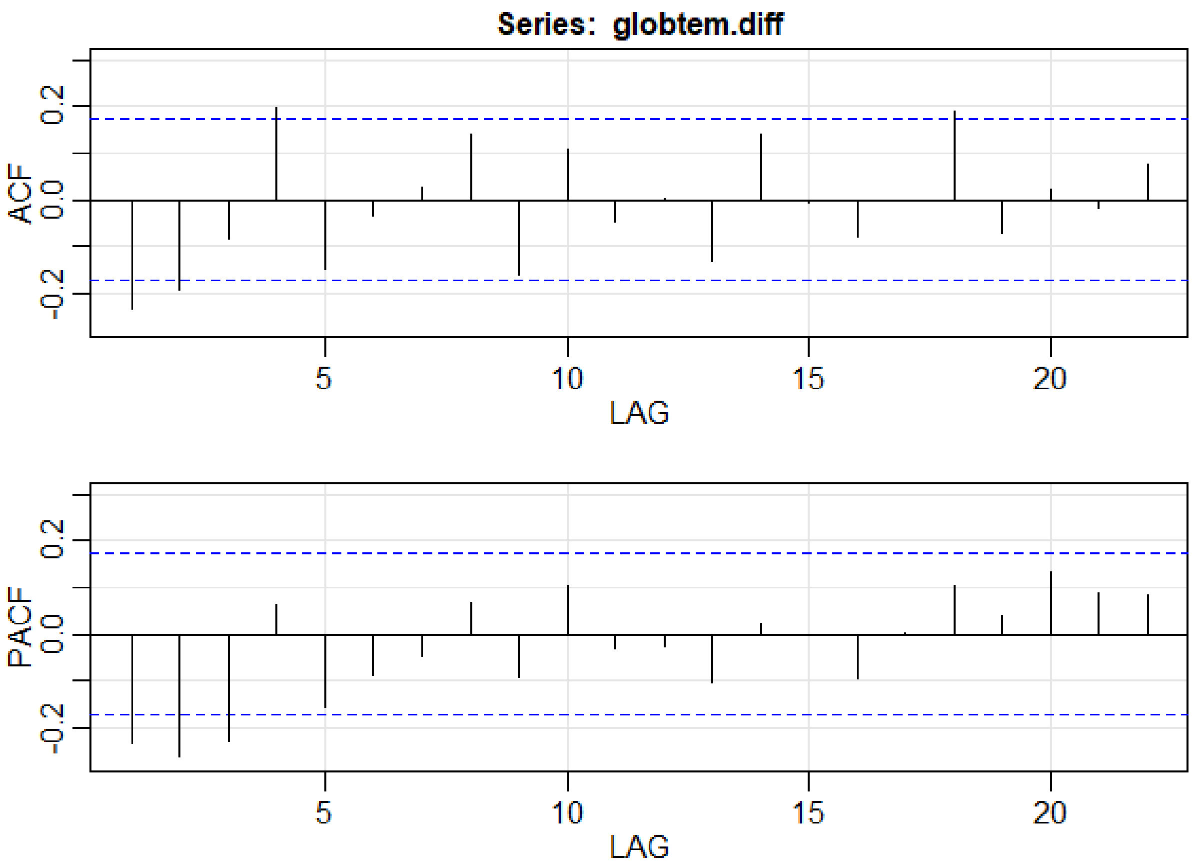
```
> acf2(globtemp)# Plot And Print ACF And PACF Of A Time Series: Max lag: sqrt n + 10
```




```
> globtem.diff<-diff(globtemp, d=1)
```



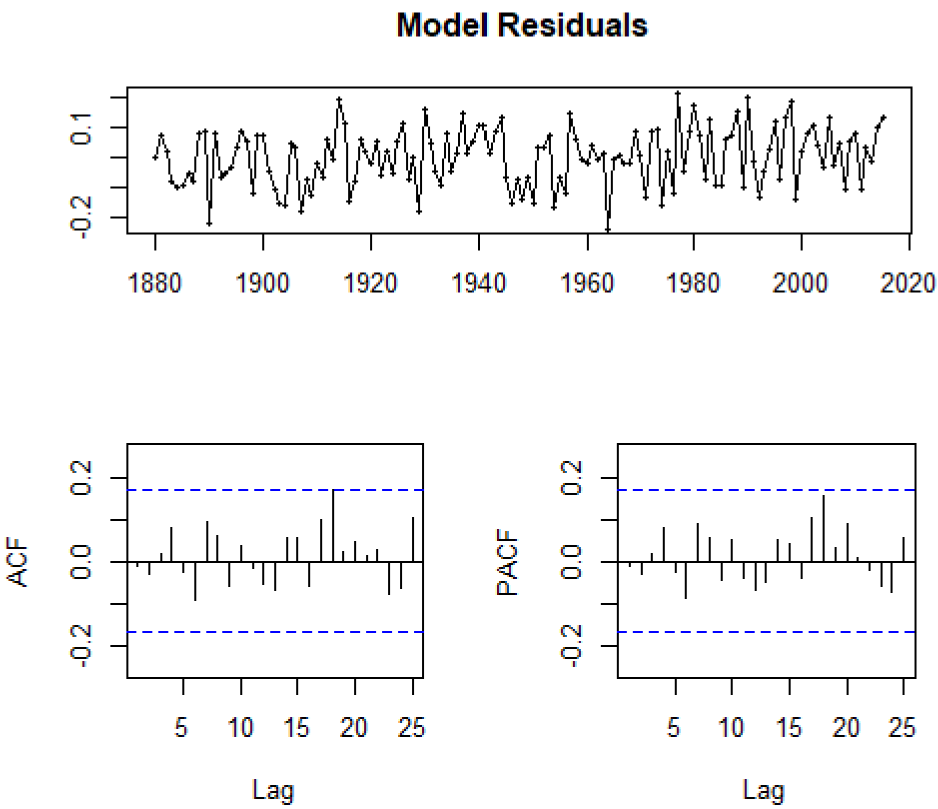
```
> kpss.test(globtemp.diff)
        KPSS Test for Level Stationarity
data:  globtemp.diff
KPSS Level = 0.1437, Truncation lag parameter = 2, p-value = 0.1
> # pvalue =0.10 we fail to reject the null hypothesis of stationarity; thus, series diff
=1 becomes stationary.
> acf2(globtemp.diff)
```



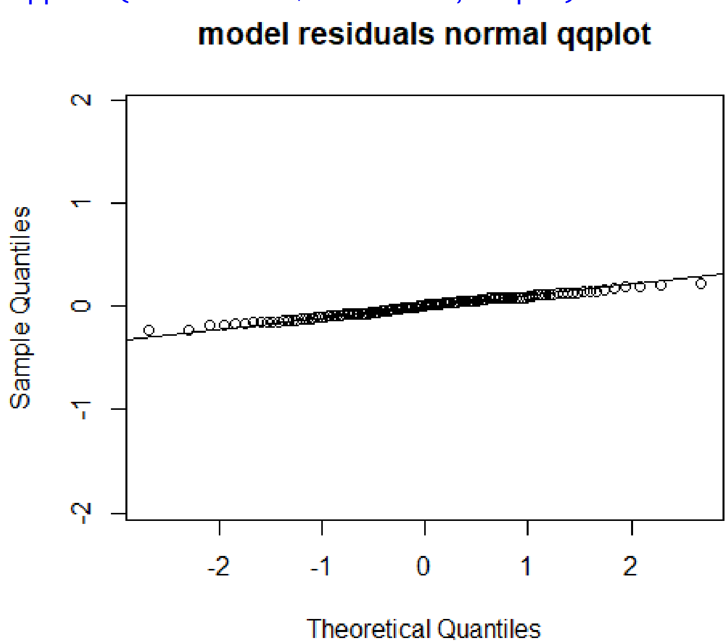

```
> auto.arima(globtemp, d = 1, max.p = 5, max.q = 5)
Series: globtemp
ARIMA(1,1,3) with drift

Coefficients:
          ar1     ma1      ma2      ma3   drift
      -0.9449  0.6081  -0.5681  -0.3091  0.0072
s.e.   0.0561  0.0970   0.0855   0.0804  0.0032

sigma^2 estimated as 0.009775:  log likelihood=123.06
AIC=-234.12   AICc=-233.47   BIC=-216.69
> arima.fit2<-Arima(globtemp, order=c(1,1,3), include.drift =TRUE, method="ML")
> arima.fit2
Series: globtemp
ARIMA(1,1,3) with drift

Coefficients:
          ar1     ma1      ma2      ma3   drift
      -0.9449  0.6081  -0.5681  -0.3091  0.0072
s.e.   0.0561  0.0970   0.0855   0.0804  0.0032

sigma^2 estimated as 0.009775:  log likelihood=123.06
AIC=-234.12   AICc=-233.47   BIC=-216.69
```

```
> confint(arima.fit)
             2.5 %      97.5 %
ar1   -1.0549132196 -0.83491695
ma1    0.4179056253  0.79826832
ma2   -0.7357233155 -0.40042177
ma3   -0.4666692104 -0.15144372
drift  0.0008865522  0.01342594
```

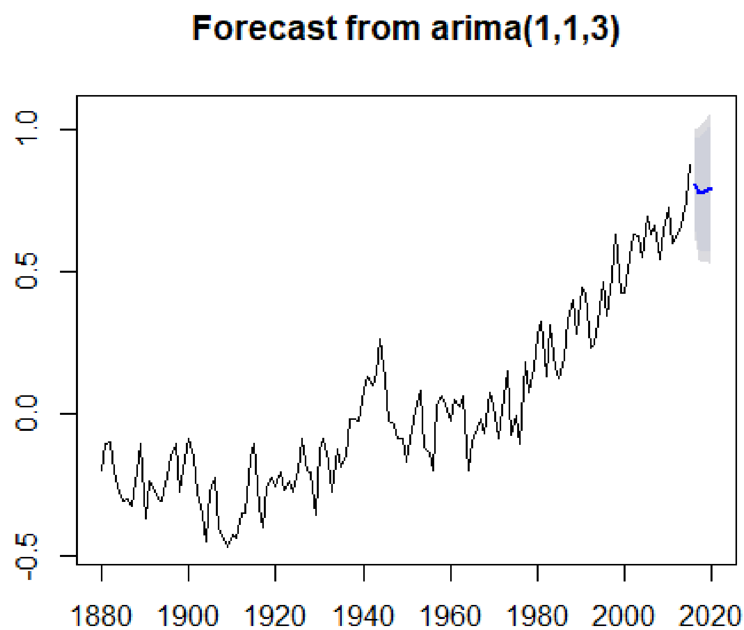
```
> tsdisplay(residuals(arima.fit2), lag.max=25, main=' Model Residuals')
```




```
># the residuals scatter around a mean near zero with no obvious trends or patterns. In a
ddition, no autocorrelation of the residuals is observed.
> qqnorm(arima.fit2$residuals, asp = 1, main="model residuals normal qqplot")
> qqline(arima.fit2$residuals, asp=1)
```



```
> pred<-forecast(arima.fit2, level=c(0.90, 0.95), h=5)
> plot(pred, main="Forecast from arima(1,1,3)")

> pred
     Point Forecast     Lo 90     Hi 90     Lo 95     Hi 95
2016      0.8020349 0.6394071 0.9646627 0.6082520 0.9958179
2017      0.7735608 0.5784212 0.9687004 0.5410377 1.0060839
2018      0.7725651 0.5661704 0.9789598 0.5266306 1.0184996
2019      0.7874242 0.5737363 1.0011122 0.5327993 1.0420491
2020      0.7873019 0.5634842 1.0111196 0.5206067 1.0539971
```




```
> arima.fit1<-Arima(globtemp, order=c(1,1,1), include.drift =TRUE, method="ML")
> arima.fit1
Series: globtemp
ARIMA(1,1,1) with drift

Coefficients:
         ar1      ma1   drift
      0.3549  -0.7663  0.0072
s.e.  0.1314   0.0874  0.0032

sigma^2 estimated as 0.01011:  log likelihood=119.88
AIC=-231.76   AICc=-231.46   BIC=-220.14
> arima.fit3<-Arima(globtemp, order=c(3,1,2), include.drift =TRUE, method="ML")
> arima.fit3
Series: globtemp
ARIMA(3,1,2) with drift

Coefficients:
          ar1      ar2      ar3     ma1      ma2   drift
      -0.7167  -0.0494  -0.2599  0.3629  -0.4592  0.0071
s.e.   0.2301   0.3107   0.1207  0.2416   0.2391  0.0038

sigma^2 estimated as 0.009854:  log likelihood=123.06
AIC=-232.11   AICc=-231.23   BIC=-211.78
```

ITSM output after diff = 1:

Model>estimation>autofit

ML estimates: C:\Users\Carlos\Desktop\globtemp.tsm

```
Method: Maximum Likelihood

ARMA Model:
X(t) = - .9448 X(t-1)
     + Z(t) + .6086 Z(t-1) - .5669 Z(t-2) - .3086 Z(t-3)

WN Variance = .009417

AR Coefficients
      -.944766

Standard Error of AR Coefficients
       .068209

MA Coefficients
       .608553      -.566927      -.308554

Standard Error of MA Coefficients
       .098901       .093448       .081106

(Residual SS)/N = .00941725

AICC = -.235601E+03
BIC  = -.234199E+03

-2Log(Likelihood) = -.246066E+03

Accuracy parameter = .100000E-08

Number of iterations = 2

Number of function evaluations = 1921036

Uncertain minimum.
```

Autofit results

	AR Order	MA Order
Min	0	0
Max	25	25

Start
Close
Cancel

	Current	Best
AR order	25	1
MA order	25	3
AICC	-.109631E+03	-.235601E+03
# fcn eval	1921036	

INFO: C:\Users\Carlos\Desktop\globtemp.tsm

```
==========
ITSM::(INFO)
==========
# of Data Points =      135

Subtracted Mean = .0079
Sample Variance = .011784
Std.Error(Sample Mean) =  .004734
(square root of (1/n)SUM{(1-|h|/r)acvf(h)}, |h|<r=[sqrt(n)])

MODEL:

ARMA Model:
X(t) = - .9448 X(t-1)
     + Z(t) + .6086 Z(t-1) - .5669 Z(t-2) - .3086 Z(t-3)

WN Variance = .009417


Garch Model for Z(t):

Z(t) = sqrt(h(t)) e(t)
h(t) = 1.000000
{e(t)} is IID N(0,1)
```