NAG Library Routine Document

G13AHF

Note: before using this routine, please read the Users' Note for your implementation to check the interpretation of ***bold italicised*** terms and other implementation-dependent details.

1 Purpose

G13AHF produces forecasts of a time series, given a time series model which has already been fitted to the time series using G13AEF or G13AFF. The original observations are not required, since G13AHF uses as input either the original state set produced by G13AEF or G13AFF or the state set updated by a series of new observations using G13AGF. Standard errors of the forecasts are also provided.

2 Specification

```
SUBROUTINE G13AHF (ST, NST, MR, PAR, NPAR, C, RMS, NFV, FVA, FSD, WA,      &
                   NWA, IFAIL)
INTEGER            NST, MR(7), NPAR, NFV, NWA, IFAIL
REAL (KIND=nag_wp) ST(NST), PAR(NPAR), C, RMS, FVA(NFV), FSD(NFV),        &
                   WA(NWA)
```

3 Description

The original time series is x_t, for $t = 1, 2, \ldots, n$ and parameters have been fitted to the model of this time series using G13AEF or G13AFF.

Forecasts of x_t, for $t = n+1, \ldots, n+L$, are calculated in five stages, as follows:

(i) set $a_t = 0$ for $t = N+1, N+2, \ldots, N+L$, where $N = n - d - (D \times s)$ is the number of differenced values in the series;

(ii) calculate the values of e_t, for $t = N+1, \ldots, N+L$, and $e_t = \phi_1 \times e_{t-1} + \cdots + \phi_p \times e_{t-p} + a_t - \theta_1 \times a_{t-1} - \cdots - \theta_q \times a_{t-q}$;

(iii) calculate the values of w_t, for $t = N+1, \ldots, N+L$, where $w_t = \Phi_1 \times w_{t-s} + \cdots + \Phi_P \times w_{t-s\times P} + e_t - \Theta_1 \times e_{t-s} - \cdots - \Theta_Q \times e_{t-s\times Q}$ and w_t for $t \leq N$ are the first $s \times P$ values in the state set, corrected for the constant;

(iv) add the constant term c to give the differenced series $\nabla^d \nabla_s^D x_t = w_t + c$, for $t = N+1, \ldots, N+L$;

(v) the differencing operations are reversed to reconstitute x_t, for $t = n+1, \ldots, n+L$.

The standard errors of these forecasts are given by $s_t = \left[V \times \left(\psi_0^2 + \psi_1^2 + \ldots + \psi_{t-n-1}^2\right)\right]^{1/2}$, for $t = n+1, \ldots, n+L$, where $\psi_0 = 1$, V is the residual variance of a_t, and ψ_j is the coefficient expressing the dependence of x_t on a_{t-j}.

To calculate ψ_j, for $j = 1, 2, \ldots, (L-1)$, the following device is used.

A copy of the state set is initialized to zero throughout and the calculations outlined above for the construction of forecasts are carried out with the settings $a_{N+1} = 1$, and $a_t = 0$, for $t = N+2, \ldots, N+L$.

The resulting quantities corresponding to the sequence $x_{N+1}, x_{N+2}, \ldots, x_{N+L}$ are precisely 1, $\psi_1, \psi_2, \ldots, \psi_{L-1}$.

The supplied time series model is used throughout these calculations, with the exception that the constant term c is taken to be zero.

4 References

None.

5 Arguments

1: ST(NST) – REAL (KIND=nag_wp) array *Input*

On entry: the state set derived from G13AEF or G13AFF originally, or as modified using earlier calls of G13AGF.

2: NST – INTEGER *Input*

On entry: the number of values in the state set array ST.

Constraint: NST $= P \times s + D \times s + d + q + \max(p, Q \times s)$. (As returned by G13AEF or G13AFF).

3: MR(7) – INTEGER array *Input*

On entry: the orders vector (p, d, q, P, D, Q, s) of the ARIMA model, in the usual notation.

Constraints:

$p, d, q, P, D, Q, s \geq 0$;
$p + q + P + Q > 0$;
$s \neq 1$;
if $s = 0$, $P + D + Q = 0$;
if $s > 1$, $P + D + Q > 0$.

4: PAR(NPAR) – REAL (KIND=nag_wp) array *Input*

On entry: the estimates of the p values of the ϕ parameters, the q values of the θ parameters, the P values of the Φ parameters and the Q values of the Θ parameters which specify the model and which were output originally by G13AEF or G13AFF.

5: NPAR – INTEGER *Input*

On entry: the number of ϕ, θ, Φ and Θ parameters in the model.

Constraint: NPAR $= p + q + P + Q$.

6: C – REAL (KIND=nag_wp) *Input*

On entry: c, the value of the model constant. This will have been output by G13AEF or G13AFF.

7: RMS – REAL (KIND=nag_wp) *Input*

On entry: V, the residual variance associated with the model.

If G13AFF was used to estimate the model, RMS should be set to S/NDF, where S and NDF were output by G13AFF.

If G13AEF was used to estimate the model, RMS should be set to S/ICOUNT(5), where S and ICOUNT(5) were output by G13AEF.

Constraint: RMS ≥ 0.0.

8: NFV – INTEGER *Input*

On entry: L, the required number of forecasts.

Constraint: NFV > 0.

9: FVA(NFV) – REAL (KIND=nag_wp) array *Output*

On exit: NFV forecast values relating to the original undifferenced series.

10: FSD(NFV) – REAL (KIND=nag_wp) array *Output*

On exit: the standard errors associated with each of the NFV forecast values in FVA.

11: WA(NWA) – REAL (KIND=nag_wp) array *Workspace*

12: NWA – INTEGER *Input*

On entry: the dimension of the array WA as declared in the (sub)program from which G13AHF is called.

Constraint: NWA $\geq (4 \times \text{NPAR} + 3 \times \text{NST})$.

13: IFAIL – INTEGER *Input/Output*

On entry: IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this argument you should refer to Section 3.4 in How to Use the NAG Library and its Documentation for details.

For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, if you are not familiar with this argument, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**

On exit: IFAIL $= 0$ unless the routine detects an error or a warning has been flagged (see Section 6).

6 Error Indicators and Warnings

If on entry IFAIL $= 0$ or -1, explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

IFAIL $= 1$

On entry, NPAR $\neq p + q + P + Q$,
or the orders vector MR is invalid (check the constraints given in Section 5).

IFAIL $= 2$

On entry, NST $\neq P \times s + D \times s + d + q + \max(Q \times s, p)$.

IFAIL $= 3$

On entry, NFV ≤ 0.

IFAIL $= 4$

On entry, NWA $< 4 \times$ NPAR $+ 3 \times$ NST.

IFAIL $= 5$

On entry, RMS < 0.0.

IFAIL $= -99$

An unexpected error has been triggered by this routine. Please contact NAG.

See Section 3.9 in How to Use the NAG Library and its Documentation for further information.

IFAIL $= -399$

Your licence key may have expired or may not have been installed correctly.

See Section 3.8 in How to Use the NAG Library and its Documentation for further information.

IFAIL $= -999$

Dynamic memory allocation failed.

See Section 3.7 in How to Use the NAG Library and its Documentation for further information.

7 Accuracy

The computations are believed to be stable.

8 Parallelism and Performance

G13AHF is not threaded in any implementation.

9 Further Comments

The time taken by G13AHF is approximately proportional to NFV $\times$ NPAR.

10 Example

The following program is based on the data derived in the example used to illustrate G13AGF.

These consist of a set of orders indicating that there are two moving average parameters (one non-seasonal, and one seasonal with periodicity 12).

The model constant is zero.

The state set contains 26 values.

In addition the residual mean-square derived when the model was originally fitted is given.

Twelve forecasts and their associated errors are obtained.

10.1 Program Text

```
    Program g13ahfe

!     G13AHF Example Program Text

!     Mark 26 Release. NAG Copyright 2016.

!     .. Use Statements ..
      Use nag_library, Only: g13ahf, nag_wp
!     .. Implicit None Statement ..
      Implicit None
!     .. Parameters ..
      Integer, Parameter               :: nin = 5, nout = 6
!     .. Local Scalars ..
      Real (Kind=nag_wp)               :: c, rms
      Integer                          :: ifail, nfv, npar, nst, nwa
!     .. Local Arrays ..
      Real (Kind=nag_wp), Allocatable  :: fsd(:), fva(:), par(:), st(:), wa(:)
      Integer                          :: mr(7)
!     .. Intrinsic Procedures ..
      Intrinsic                        :: max
!     .. Executable Statements ..
      Write (nout,*) 'G13AHF Example Program Results'
      Write (nout,*)

!     Skip heading in data file
      Read (nin,*)
```

```
!     Read in problem size etc
      Read (nin,*) nfv, c

!     Read in the orders
      Read (nin,*) mr(1:7)

!     Calculate NPAR and various array lengths
      npar = mr(1) + mr(3) + mr(4) + mr(6)
      nst = mr(4)*mr(7) + mr(5)*mr(7) + mr(2) + mr(3) + max(mr(1),mr(6)*mr(7))
      nwa = 4*npar + 3*nst

      Allocate (fsd(nfv),fva(nfv),par(npar),st(nst),wa(nwa))

!     Read in parameter estimates
      Read (nin,*) par(1:npar)

!     Read in state set from G13AEF, G13AFF or G13AGF
      Read (nin,*) st(1:nst)

!     Read in residual variance
      Read (nin,*) rms

!     Produce forecasts
      ifail = 0
      Call g13ahf(st,nst,mr,par,npar,c,rms,nfv,fva,fsd,wa,nwa,ifail)

      Write (nout,99998) 'The required', nfv,                                &
        ' forecast values are as follows'
      Write (nout,99999) fva(1:nfv)
      Write (nout,*)
      Write (nout,*)                                                         &
        'The standard deviations corresponding to the forecasts are'
      Write (nout,99999) fsd(1:nfv)

99999 Format (1X,8F8.4)
99998 Format (1X,A,I3,A)
    End Program g13ahfe
```

10.2 Program Data

```
G13AHF Example Program Data
  12  0.0                                                       :: NFV,C
   0   1   1   0   1   1   12                                   :: NR
  0.3270  0.6262                                                :: PAR
  0.0660 -0.0513  0.1715 -0.0249  0.0588  0.1167  0.1493  0.0199
 -0.1884 -0.1289 -0.1172  0.1122  6.0039  0.0443 -0.0070  0.0252
  0.0020  0.0353 -0.0460  0.0374  0.0151 -0.0237  0.0031  0.0188
  0.0066  0.0125                                                :: End of ST
  0.0014                                                        :: RMS
```

10.3 Program Results

```
 G13AHF Example Program Results

 The required 12 forecast values are as follows
   6.0381  5.9912  6.1469  6.1207  6.1574  6.3029  6.4288  6.4392
   6.2657  6.1348  6.0059  6.1139

 The standard deviations corresponding to the forecasts are
   0.0374  0.0451  0.0517  0.0575  0.0627  0.0676  0.0721  0.0764
   0.0805  0.0843  0.0880  0.0915
```