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PARAMETERIZATION OF
DIRECTIONAL SPECTRA – PART 2
Volume II: USER'S MANUAL FOR
THE PROGRAMS RMODEL, FITHM AND
FITDM

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ABSTRACT

Software was developed to perform a non-linear, least-squares fit of the Ochi and Hubble (1976) six-parameter heave and an extended 10-parameter, directional, wave model to spectra produced by the ODGP hindcast numerical model. The necessary programs RMODEL, FITHM and FITDM were documented including a description of the unit numbers addressed, subroutines used, with appropriate calling sequences, the arrays and variables assigned, and any necessary user interaction required.

RÉSUMÉ

Un logiciel a été mis au point pour la réalisation d'un ajustement non linéaire par la méthode des moindres carrés du modèle ondulatoire à six paramètres de Ochi and Hubble (1976) et d'un modèle ondulatoire directionnel étendu à 10 paramètres, aux spectres produit par le modèle numérique post-analyse ODGP. On a redigé la documentation relative aux programmes nécessaires RMODEL, FITHM et FITDM, y compris la description des numéros d'unité appelés, les sous-routines utilisées avec les séquences d'appel correspondantes, les matrices et variables assignées, et toute interaction utilisateur nécessaire.

TABLE OF CONTENTS

1. INTRODUCTION

This booklet provides the necessary information for the running of the file reading program RMODEL and the non-linear least-squares fitting programs FITHM and FITDM with specific application to ODGP hindcast directional wave spectra. RMODEL initially converts the ODGP hindcast model spectral format into a more applicable form. FITHM performs a fit of the Ochi and Hubble (1976) six-parameter model given by:

$$S(\omega) = \frac{1}{4} \sum_{i=1}^{2} \frac{(4\lambda_i + 1}{4} \ \omega m_i^4)^{\lambda_i} \ \delta_i^2 \ e^{-\frac{(4\lambda_i+1)}{4}\frac{(\omega m_i)^4}{\omega}}}{\Gamma(\lambda_i)\omega^{4\lambda_i+1}} \tag{1}$$

where ωm_i represents the modal frequency (radians/sec), δ_i the significant wave height (meters) and λ_i a shape parameter to the transformed ODGP hindcast spectrum. This model was extended to include four direction parameters having the functional form:

$$M(\omega,\theta) = \frac{\frac{1}{4} \sum_{i=1}^{2} \frac{(4\lambda_i + 1}{4} \ \omega m_i^4)^{\lambda_i} \ \delta_i^2 \ e^{-\frac{(4\lambda_i+1)}{4}\frac{(\omega m_i)^4}{\omega}} * A(P_i)\cos^{2P_i}\left(\frac{\theta - \theta m_i}{2}\right)}{\Gamma(\lambda_i)\omega^{4\lambda_i+1}} \tag{2}$$

where P_i controls the directional spread, Θm_i represents the mean wave direction and the function A(PI) corrects for the area under a COS2Pi curve, FITDM performs the nonlinear fit of Eq. 2 to the complete directional spectrum. Further details on the model, its applicability and behavior when applied to field measured data and to hindcast spectra can be found in an accompanying report by Juszko (1989) and in volume I of the present report.

2. RMODEL – Format Conversion

2.1 Input and Output

RMODEL converts the stored ODGP hindcast directional spectra into a format required as input to FITHM and FITDM. A sample of the stored format is provided in Appendix 1A , RMODEL removes character strings and blank lines, converts the day of month and month to Julian day (JDAY) and the stored energy entries (units of m**2) into energy spectral densities (units of m**2/radians per sec – radians). The number of directional entries are variable and RMODEL pads the missing directions with zeros to supply a constant 15 by 24 frequency – direction array.

On output, the wave data file contains a file header, followed by individual records each consisting of a record header and 24 lines of spectral density information. A sample of the output is included in Appendix 1B .

File Header Format:
```
    Line 1:  Grid Point, Latitude, Longitude
             I6, 1X, F8.3, 1X, F8.3
    Line 2:  Frequency Array (in radians)
             15 (1X, F7.5)
    Line 3:  Bandwidth Array (in radians)
             15 (1X, F7.5)
```

Record Header Format:
```
    Line 1:  IYR, JDAY, IHR, WSPDF, WDIR, HS, TS, VMD, TP
             1X, I2, I3, I2, 6 (1X,F6.2)
             where
             IYR :   year of record
             JDAY:   Julian day
             IHR :   hour of record
             WSPD:   wind speed (m/s)
             WDIR:   wind direction (degrees true "from")
             HS  :   significant wave height (m)
             TS  :   significant period (s)
             VMD :   vector mean direction (degrees true "to")
             TP  :   peak period (s)
```

Record Format:
```
    24 lines:   E(I,J), J=1,15
                15F8.5
             where I bins contains energy going "to" directions
         associated with  the  angles  15*(I-1)  to  15*I  and  having
         nominal directions of 7.5+15*(I-1) degrees
```

2.2 Constants, Variables and Arrays

INPUT

IYR   Year (INTEGER)

IM   Month of year (INTEGER)

ID   Day of month (INTEGER)

IHR   Hour of day (INTEGER)

IGRP   Grid point number (INTEGER)

LAT   Latitude (REAL)

LONG   Longitude (REAL)

WSPD	Wind speed in m/s (REAL)
WDIR	Wind direction in degrees true –"From" (REAL)
HS	Significant wave height in m (REAL)
TS	Significant period in sec (REAL)
VMD	vector mean direction in degrees true – "To" (REAL)
TP	Peak period in sec (REAL)
FILL	Dummy variable (CHARACTER*1)
E	Array of energies per direction bin in m**2 (REAL(15))
FR	Array of frequencies (Hz) (Real(15))

PROCESSING

HS2	Significant wave height of converted records in m (REAL)
IB	Array of days in month (INTEGER(12))

OUTPUT

IYR	Year (INTEGER)
JDAY	Julian day (INTEGER)
IHR	Hour of day (INTEGER)
FR	Array of frequencies (radians/sec) (REAL(15))
DFR	Array of frequency bandwidths (radians/sec) (REAL(15))
EN	Two-dimensional spectral densities (m**2/RPS–Radians) (Real (24,15))

IGRP, LAT, LONG, WSPD, WDIR, HS, TS, VMD, TP as in input.

2.3 Program Operation

When initiated, RMODEL will ask for the input filename of stored ODGP hindcast spectra and the output filename of converted records. The format of stored ODGP spectra may vary slightly between sources (eg. No. of blank lines at the beginning of the file) and RMODEL may have to be adjusted accordingly. For each record, the program currently writes to the screen the record header information and the newly calculated significant waveheight.

**The program checks for an error on the direction array read statement in order to locate the end of each record and for proper

running on an IBM-AT, a blank line is required as the last line of the input file.

3. FITHM – Ochi and Hubble Six–Parameter Model

3.1 Input and Output

Throughout the program, unless otherwise specified, day is julian, times are in hours (as HH, eg. 6,12), frequencies in radians/sec, lengths in meters and directions in radians. Data input is through Unit=1 using the LOADM subroutine, discussed in section 3.3 , to input individual frequency spectrum which will be fit to the model (Eq. 1). The input file has the format structure of the output of RMODEL discussed in Section 2 and a sample is included in Appendix 1b .

Program output is to file FITH.LOG assigned Unit=2. The first line of the output file contains the grid point number and its location information. Each subsequent line of the output file consists of the individual record time, day and year, wind speed (WSPD) and wind direction (WDIR), the six fitted parameters, the number of iterations performed, and the weighted least-squares error (RESH) given by:

$$\text{RESH} = \frac{\sum_{I=1}^{N} [E(\omega_I) - S(\omega_I)]^2 WT_I^2}{\sum_{I=1}^{N} [E(\omega_I)]^2 WT_I^2} \qquad (3)$$

where $E(\omega)$ is the hindcast spectral value at frequency ω, $S(\omega)$ is the corresponding fit value and WT is a weighting factor for each frequency equal to the corresponding bandwidths divided by the sum of all bandwidths. The sum is performed over all frequencies.

Format of output:

File Header: Grid Point ID, Latitude, Longitude
             I6,1X,F8.3,1X,F8.3
Record:
    YEAR,TIME,JDAY,WSPD,WDIR(A(J),J=1,6)ICOUNT,RESH
    1X,I2,I4,I3,2(1X,F6.2),6(1X,F9.6),I4,1X,F7.5

where $A(1) = \delta 1$ $A(4) = \delta 2$
           $A(2) = \omega m1$ $A(5) = \omega m2$
           $A(3) = \lambda 1$ $A(6) = \lambda 2$

A sample of the output file is included in Appendix 2 .

3.2 Primary Constants, Variables and Arrays

```
INPUT

NFRQ            No. of frequencies in amplitude spectrum (INTEGER)

FIRST           Allows for initialization of any necessary counters in
user supplied LOADM subroutine and for random entry into a large data
file. Set to FALSE by LOADM after first call. (LOGICAL)

JFLAG           Flag to allow a record to be skipped in the processing
(eg. bad data record) and to provide notice of the end of the input
file (0= no skipping, 1 =yes, 9=End of file)(INTEGER)

IYRIN           Year of first record (INTEGER)

ITIN            Time of first desired record (INTEGER)

IDIN            Day of first desired record (INTEGER)

IGP             Grid point identification (INTEGER)

IYRI            Current record year (INTEGER)

IT1             Current record time (INTEGER)

ID1             Current record day (INTEGER)

IOREC           Record counter (INTEGER)

LAT             Latitude (REAL)

LONG            Longitude (REAL)

WSPD            Wind speed (REAL)

WDIR            Wind direction (REAL)

X               Array of frequencies in radians/sec (REAL(15))

Y               Array of spectral energy values in m**2/rps
                (REAL (15))

FG,HG           Work  arrays  to  find  position  of  spectral  peaks
(REAL(15))

EN              Two-dimensional    input    spectral    density    array
M**2/rps-rad (REAL(24,15))

PROCESSING

NCOEF           Number of model parameters (INTEGER)

NVAL            Number of parameters fitted (INTEGER)

NMAX            Maximum  dimension  of  the  fitting  matrices  A  and  B
(INTEGER)
```

IFLAG   Flag to indicate if matrix is singular (INTEGER)

INCR   Counter for the number of iterations in a row which did not improve the fit. At INCR=15, the fit is terminated (INTEGER)

LAMDA   Variable controlling the rate of steepest descent (REAL)

ICHAN   Flag allowing for a second processing if $\omega m2>1.696$ or if frequency separation is less than .001 which ensures proper modelling of low frequencies (INTEGER)

ICOUNT   Counter for number of iterations used (INTEGER)

MCOUNT   Counter for number of iterations in a row if the relative change in CHISQ is less than or equal to 2.E-5 (INTEGER)

CHISQ   Chi-squared value calculated after each iteration and used to assess the fit improvement. Initially set to 1.0E30 in order to force an improvement in first iteration. CHISQN, CHISQL, CHISQF are storage locations for the chi-square value. (REAL)

YEST   Model heave value for a given frequency and set of parameter values (REAL)

COEF   Array of fit parameters. Also stored in
                   COEFO, COEFT and CL, (REAL(6))

LIST   Array of parameter indices (INTEGER(6))

DYDA   Array of first derivative values (REAL(6))

DCOF   Array of parameter change (REAL(6))

WT   Array of weights for chi-square calculation (REAL(15))

B,BT   Working array for fitting vector (REAL(6))

A,AT   Working array for fitting matrix (REAL(6,6))

OUTPUT

ICOUNT   Number of iterations (INTEGER)

RESH   Residual error (REAL) (as in Eq. 3)

COEFO   Array of fit parameters (REAL(6))

IYR1, IT1, ID1, IGP, WSPD, WDIR, LAT and LONG as in input.

3.3 Subroutines

LOADM   (IU,X,Y,ITIN,IDIN,IYRIN,IYR1,IT1,ID1,NFRQ,DFR,WSPD,WDIR,JFLAG,
FIRST,IOREC)

Subroutine LOADM, called by the main program FITHM, is specifically designed for this application. IU is the input unit number generally set to 1. The amplitude spectral estimates are returned in the array Y along with the number of frequencies (NFRQ). The frequency array, X, and bandwidth DFR is currently being read from the input file. Any changes to the spectrum (eg. smoothing) should be performed in this subroutine as no further modifications are performed on Y in the main program. JFLAG allows for skipping of records (when set to 0) and serves as notification for the end of the input file (JFLAG=9). FIRST is used to indicate the first call to LOADM to allow for file opening, initialization of input file counters and reading of file headers. The input file is read, without record processing, until year, day and time of the record match the requested IYRIN, IDIN and ITIN values.

All following records are currently being processed.

LEMARQ (X,Y,NFRQ,COEF,COEFO,NCOEF,LIST,NVAL,CHISQ,LAMDA,INCR,AT,BT)

Subroutine LEMARQ, called by FITHM, controls the iteration procedure, evaluates the fitting matrix and coefficient values. It uses the Levenberg-Marquardt method to perform the non-linear fit and details on this procedure can be found in Press et. al.(1986). Any necessary fit constraints are handled by this subroutine. The fitting matrices AT and BT and the coefficient values COEFO must remain unaltered between calls to LEMARQ. The value of LAMDA is determined within the subroutine for the steepest descent calculations. If INCR is returned with a value of 15, the iterations are stopped. IFLAG is held in a common statement and is set to 1 if the fit matrix is singular and cannot be inverted. The iterations are stopped at this point.

GAUSS (A,B,NVAL,NMAX,DCOF)

Subroutine GAUSS is called by LEMARQ and calculates the matrix solution.

CHICAL (X,Y,NFRQ,COEF,NCOEF,CHISN)

Subroutine CHICAL is called by LEMARQ and calculates the weighted chi-square residual value.

GAMMLN (XL)

GAMMLN is a functional subroutine which returns the value of LN [Γ(XL)] for XL>0.0.

FUNC (XX,COEF,Y1,Y2,YEST)

Subroutine FUNC is called by CHICAL, LEMARQ and FITHM. This subroutine evaluates the total model spectral density (YEST) as well

as the individual components (Y1 and Y2) for an input frequency XX and current values of the parameter array COEF.

DERIV (XX,COEF,Y1,Y2,DYDA)

Subroutine DERIV is called by LEMARQ and supplies the first derivative values (DYDA) of the function with respect to each parameter (COEF) and frequency (XX) given the previously calculated Y1 and Y2 estimates.

F1 (XL)

F1 is a functional subroutine called by FUNC to calculate the first derivative

evaluated at λ = XL.

$$\frac{\partial \, LN \, \Gamma(\lambda)}{\partial \, \lambda}$$

3.4 Program operation

When initiated, FITHM will ask for the time, day and year of the first record to be processed and the input filename. This information is normally entered at a console. No further user interaction is required. The user supplied LOADM subroutine needs to access this input file to obtain the current heave spectral array for fitting. Unless specified by JFLAG, each record in the input file will be processed. The current record time, Julian day, year and record counter are written to the console. This forms part of a large loop which is terminated when JFLAG is returned with a value of 9.

For each record, the heave array is scanned for peaks as part of a first guess procedure, the iterative fit is performed (terminated at given set values of ICOUNT, MCOUNT and INCR currently 100, 15 and 10, respectively; or if IFLAG is returned with a value of 1), and the RESH error is calculated. An optional second processing is included if the $\omega m2$ value is greater than 1.696 or if the frequency separation is less than .001 to ensure proper modelling of lower frequencies when there is little energy at high frequencies. The best results are written to the output file FITH.LOG. At each iteration, current values of ICOUNT, CHISQ and the fit parameters can be written to the console. The corresponding write statements in FITH are presently commented out to speed up the processing. The final fit parameters and RESH values are written to the screen for each record. Further background information on the first guess procedure and fitting constraints can be found in Juszko (1989) and Volume I of this report.

4. FITDM – Ten Parameter Model

4.1 Input and Output

Throughout the program, unless otherwise specified, day is Julian, time is in hours (HH eq. 6,12), frequencies in radians/sec,

lengths in meters and directions in radians. Data input of the
directional spectrum is through Unit=1 with use of the LOADDM
subroutine. The first guesses for the six heave parameters are taken
from the output of program FITHM and read from unit=3 assigned to file
specified by the user, samples of the input files are given in
Appendix 1b and 2

Program output is to file FITDM.LOG (Unit=2), a sample of which
is contained in Appendix 3 . A file header is initially written to
the output file containing the grid point number and location
information. Each following line of the output file consists of the
individual record time, day and year, wind speed (WSPD) and wind
direction (WDIR), the ten fitted parameters, the fit chi-square
residual, the number of iterations performed, the significant
waveheight of the input spectra and of the fit spectra, the residual
least-squares error (RESD) given by:

$$
\text{RESD} = \frac{\sum_{i=1}^{N} \sum_{j=1}^{M} [\, D(\omega_i, \theta_j) - M(\omega_i, \theta_j)\,]^2 \, WT_i^2}{\sum_{i=1}^{N} \sum_{j=1}^{M} [\, D(\omega_i, \theta_j)\,]^2 \, WT_i^2}
\tag{4}
$$

where $D(\omega, \Theta)$ is the input spectral value at frequency ω and direction
Θ and $M(\omega, \Theta)$ is the corresponding fit value. WT is a weighting factor
given by the frequency bandwidth divided by the sum of all bandwidths
examined. The sum is performed over all frequencies and directions.

Format of output:

File Header: Grid Point Number, Latitude, Longitude
               I6,1X,F8.3,1X,F8.3

Records: YEAR,TIME,DAY,WSPD,WDIR,(A(J),J=1,10),ICOUNT,HS1,HS2,
           RESD
           1X,I2,I4,I3,2(1X,F6.2),10(1X,F10.5),I4,2(1X,F5.2),1X,F7.5

where   A(1) = $\delta1$ A(6) = $\delta2$
           A(2) = $\omega m1$ A(7) = $\omega m2$
           A(3) = $\lambda1$ A(8) = $\lambda2$
           A(4) = $\Theta m1$ A(9) = $\Theta m2$
           A(5) = P1   A(10)= P2

The program output currently supplies A(4) and A(9) in radians with a
convention consistent with the input spectra (ie. going "to" in the
case of hindcast spectra). This can easily be changed as coming "from"
by an addition of pi radians to both components.

4.2 Primary Constants, Variables and Arrays

INPUT

NFRQ,NF	Number of frequencies in input spectrum (INTEGER)
NDIR,ND	Number of direction bins in input spectrum (INTEGER)
ITIN	Time of first desired record (INTEGER)
IDIN	Day of first desired record (INTEGER)
IYRIN	Year of first desired record (INTEGER)
IT1,2	Current record time (INTEGER)
ID1,2	Current record day (INTEGER)
IYR1,2	Current record year (INTEGER)
IGP	Grid point number (INTEGER)
LAT	Latitude (REAL)
LONG	Longitude (REAL)
DDIR	Direction resolution (REAL)
WSPD	Wind speed (REAL)
WDIR	Wind direction (REAL)
TOTW	Sum of all frequency bandwidths (REAL)

FIRST   Allows for initialization of any counters in user supplied subroutine LOADDM and allows for random entry into a large data file. Set FALSE after first call and reset to TRUE when the end of file is reached. Once processing is initiated all subsequent records are processed. (LOGICAL)

W	Frequency array (REAL(15))
DFR	Frequency bandwidth array (REAL(15))
X	Direction array set to go from –pi+DDIR/2 to pi+DDIR/2 (REAL(25))
X1	Work array of directions used in centering (REAL(25))
Y	Array of En(Θ) values at a given frequency (REAL(25))
XCOEF	Coefficient array fox fit, at a given frequency, to a cosine–2P expression (REAL(4))

AINIT   Six heave fit parameters (REAL(6))

E   Directional spectrum array (REAL(25,15))

PROCESSING

NVAL   Number of model parameters fitted(INTEGER)

NCOEF   Number of model parameters (INTEGER)

NMAX   Maximum dimension of fitting matrices A and B (INTEGER)

IFLAG   Flag to indicate if matrix is singular (Set to 1 if singular and iterations are stopped) (INTEGER)

ICOUNT   Counter for number of iterations performed (INTEGER)

MCOUNT   Counter for number of iterations in a row if the relative change in CHISQ is less than or equal to 1.E-3 (INTEGER)

INCR   Counter for number of iterations which result in an increase in chi-square. If INCR=10, the fit is terminated. (INTEGER)

CHISQ   Chi-squared value calculated after each iteration and used to assess fit improvement. Also stored in CHISN, CHISQL.(REAL)

LAMDA   Controls the rate of steepest descent (REAL)

YMOD,YEST   Model heave value for a given frequency, direction and set of parameter values (REAL)

COEF   Array of 10 model parameters. Also stored in COEFO, COEFL and COEFLL, (REAL(10))

LIST   Array of parameter indices (INTEGER(10))

DYDA   Array of first derivative values (REAL(10))

Y   Array of $EN(\Theta)$ values at a given frequency (REAL(25))

XI   Work array for direction used during centering of direction array (REAL(25))

XNEW   Centered direction array modified between iterations (REAL(25,15))

A,AT   working array for fitting matrix (REAL(10,10))

B,BT   Working array for fitting vector (REAL(10))

OUTPUT

ICOUNT   Counter for the number of iterations (INTEGER)

HSF1   Significant wave height of input spectra (REAL)

HSF2   Significant wave height of fit spectra (REAL)

RESD   Least-square residual (REAL) (as in Eq. 4)

COEFO   Array of fit parameters (REAL(10))

IYR2, IT2, ID2, WSPD, WDIR, IGP, LAT and LONG as in input.

4.3 Subroutines

LOADDM(IU,E,W,X,AINIT,ITIN,IDIN,IYRIN,IYR1,IT1,ID1,NFRQ,DFR,NDIR,WSPD,
WDIR,FIRST)

    Subroutine LOADDM is called by the main program FITDM. IU is the
input unit number generally set to 1. The two-dimensional spectral
array is returned in E currently dimensioned at 25 directions by 15
frequencies (ie. direction 1= direction 25). The user is asked to
enter both the input spectral filename and the filename of the six
parameter heave fit results. Frequency array W and direction array X
are set by LOADDM using information held in data statements in FITDM.
The direction convention is from -PI+DDIR/2 to PI+DDIR/2 (hence the
direction dimensions of NDIR+1) with the equivalently indexed spectral
densities assigned to them. FIRST is used to indicate the first call
to LOADDM for initialization. It is set to FALSE in LOADDM after first
call and reset to TRUE when the end of file is reached.

INIT2 (X,X1,Y,NDIR,XCOEF)

    Subroutine INIT2 is called by FITDM to perform a fast fit of the
En(Θ) array (stored in Y) for a given frequency to the equation:

$$Y(\theta) = A \cos^{2P}\left(\frac{\theta - \theta m}{2}\right) + \alpha \qquad (5)$$

to obtain the first guesses for COEF(4) or COEF(9) (P values) and for
COEF(5) or COEF(10) (mean directions). These are returned as XCOEF(4)
and XCOEF(4) respectively (XCOEF(2)= α and XCOEF(3)=A). X is the
direction array, X1 a work array and NDIR is the input no. of
directions (eg. 24).

CENTER (X,X1,Y,NDIR,DIRM)

    Subroutine CENTER is called by FITDM and performs the centering
of the direction array about an input direction, DIRM. X is the
initial direction array and X1 the new centered array. NDIR is the
input no. of directions (eg. 24). Y is the En(Θ) array corresponding
to X.

LEMARQ4 (W,XNEW,E,ND,NF,COEF,COEFO,NCOF,LIST,NVAL,CHISQ,LAMDA
    ,INCR,AT,BT

    Subroutine LEMARQ4 is called by FITDM and controls the iterative fit procedure. Any necessary fit constraints aye handled by this subroutine and evaluates the fitting matrices (A,AT) and vector (B,BT). The parameter LAMDA controls the rate of descent when the proposed coefficient values result in an increase in chi-square residual. The fitting matrices AT and BT and the coefficient values COEFO must remain unaltered between calls to LEMARQ4.

CHICAL4 (W,XNEW,E,ND,NF,COEF,NCOF,CHISN)

Subroutine CHICAL4 is called by LEMARQ4 and calculates the chi-square residual.

GAUSS (A,B,NVAL,NMAX,DCOF)

    Subroutine GAUSS is called by LEMARQ4 and calculates the matrix solution.

GAMMLN(XL)

    GAMMLN is a functional subroutine which returns the value of LN Γ(XL) for XL>0.0.

FUNC3 (XW,XD,COEF,YEST,DYDA,NVAL)

    Subroutine FUNC3 is called by LEMARQ4 in order to evaluate the model spectral density (YEST) and the first derivatives (DYDA) for all 10 parameters. COEF is the array of parameters and XW and XD are the frequency and direction currently being evaluated.

FUNC2 (XW,XD,COEF,Y1,Y2,YEST)

    Subroutine FUNC2 is called by FITDM and CHICAL4 to evaluate the model estimate having a given set of COEF values and at the current frequency and direction position XW and XD.

FUNC2F (XW,XD,COEF,YI,Y2,YMOD)

    Subroutine FUNC2F is not used by FITDM but is included as it contains the complete model expression needed to regenerate the directional spectra from the output 10 fit parameters.

FL(XL)

    F1 is a functional subroutine called by FUNC3 to calculate the first derivative

evaluated at λ = XL. $\dfrac{\partial \text{ LN } \Gamma(\lambda)}{\partial \lambda}$

4.4 Program operation

FITDM currently assumes that the input spectra consist of 15 frequencies and 24 directions. Hence, the relevant array dimensions are set at 15 and 25 (ie. to allow for wraparound in direction $X(1)=X(25)$). Changes to the dimension statements may be required for different input data sets. The input direction array is taken as $-PI+DDIR/2$ to $PI+DDIR/2$ to allow for ease in centering the spectrum during the fit. The output mean direction parameter values are associated with the same direction convention as the input spectra, and depending on the desired orientation and input convention, a value of PI may be added to these coefficients. In the case of the ODGP hindcast data, the output convention is "to".

When initiated, FITDM will ask for the time, day and year of the first record to be processed and the filenames for the files containing the input spectra and the input six heave parameters(taken as FITH,LOG). No further user interaction is required.

The program accesses the file FITH,LOG to obtain the record time and the first guesses for the heave parameters. A user supplied LOADDM subroutine needs to access an input data file in order to retrieve the corresponding directional spectrum ($D(\omega,\Theta)$). The current time, Julian day, year and record counter are written to the console. This forms part of the large loop which processes the individual records and outputs the results to FITDM,LOG. The loop is terminated when an end-of-file mark is encountered on the read of the data file. The program will start at any desired record contained in FITH,LOG after which all consecutive records are processed. It is assumed that both the spectral file and FITH.LOG file contain exactly corresponding records.

For each record, the input AINIT array from FITH.LOG is used as the first guess for the heave parameters and an initial fit of Eq. 5 to the energy direction array at the nearest frequencies to $\omega m1$ and $\omega m2$ supplies the first guess to the direction parameters. The program checks for bimodality when the two input frequencies are equal. The non-linear fit is then performed. At each iteration, chi-squared, counter and fit parameter information can be written to the screen though these statements axe currently commented out to speed up program operation. iterations are terminated at set values of ICOUNT MCOUNT and INCR (50,7 and 10, respectively). The final RESD and parameter values are written to the screen for each record. The user may want to remove some or all of these write statements in order to speed up the program, free the terminal or if no monitoring of program progress is required. If the RESD value is greater than 20%, a second processing is performed using the previous records 10-parameter fit results as the initial guesses. In these situations the best fit results will be output.

Further background information on the first guess and centering procedure, as well as fit constraints, can be found in volume I of this report.

5. REFERENCES

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APPENDIX 1.

Appendix 1A.   Sample printout of stored ODGP hindcast spectra.
                File: MODEL.DAT

Appendix 1B.   Sample output file from RMODEL. File: HIND.DAT

```
$WHO
MARCH   =      41,
PRINT   = 1106.000    , 107*0.0000000E+00
$END

YM  DH        GP     LAT     LONG    M/SEC   FROM    U*      HSIG    TSIG    VMD     TPEAK
8402.2706.   1106.  46.250  -48.75   10.27   222.17  0.375   4.53    8.15    44.84   10.30

FREQUENCY   0.04047 0.04440 0.05000 0.05556 0.06111 0.06670 0.07222 0.08056 0.09167 0.10278 0.11667 0.13333 0.15833 0.20833 0.30833
DIRECTION
    7.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00001 0.00008 0.00205 0.01266 0.02264 0.02727 0.01822 0.01742 0.01067 0.00349
   22.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00009 0.00093 0.00821 0.02680 0.03122 0.03290 0.01974 0.01764 0.01068 0.00411
   37.5     0.00000 0.00000 0.00000 0.00001 0.00013 0.00094 0.00296 0.02107 0.03750 0.03604 0.03582 0.01997 0.01777 0.01024 0.00443
   52.5     0.00000 0.00000 0.00000 0.00016 0.00121 0.00375 0.01130 0.04419 0.04667 0.03610 0.03413 0.01910 0.01765 0.00989 0.00435
   67.5     0.00000 0.00001 0.00001 0.00027 0.00286 0.01062 0.02030 0.05300 0.04304 0.03187 0.03193 0.01890 0.01761 0.00966 0.00391
   82.5     0.00000 0.00000 0.00000 0.00008 0.00125 0.00609 0.00991 0.02312 0.02325 0.02254 0.02598 0.01690 0.01564 0.00900 0.00321
   97.5     0.00000 0.00000 0.00002 0.00002 0.00028 0.00086 0.00139 0.00328 0.00338 0.00367 0.00614 0.00832 0.01095 0.00762 0.00245
  112.5     0.00000 0.00000 0.00000 0.00000 0.00001 0.00006 0.00010 0.00023 0.00021 0.00025 0.00060 0.00137 0.00287 0.00352 0.00184
  127.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00001 0.00001 0.00002 0.00005 0.00009 0.00009 0.00152
  262.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00001 0.00001 0.00002 0.00000 0.00000 0.00000 0.00000 0.00000
  277.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00002 0.00002 0.00000 0.00000 0.00000 0.00000 0.00000
  292.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00002 0.00007 0.00013 0.00013 0.00004 0.00001 0.00000 0.00000
  307.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00006 0.00033 0.00101 0.00084 0.00146 0.00265 0.00000 0.00000
  322.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00001 0.00017 0.00091 0.00297 0.00303 0.00618 0.00573 0.00160
  337.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00008 0.00073 0.00271 0.00787 0.00832 0.01182 0.00783 0.00204
  352.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00001 0.00003 0.00064 0.00307 0.00882 0.01672 0.01269 0.01420 0.00961 0.00273


YM  DH        GP     LAT     LONG    M/SEC   FROM    U*      HSIG    TSIG    VMD     TPEAK
8402.2712.   1106.  46.250  -48.75   11.72   240.13  0.449   4.14    7.79    46.43   9.96

FREQUENCY   0.04047 0.04440 0.05000 0.05556 0.06111 0.06670 0.07222 0.08056 0.09167 0.10278 0.11667 0.13333 0.15833 0.20833 0.30833
DIRECTION
    7.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00001 0.00004 0.00113 0.00826 0.01787 0.02297 0.01942 0.01803 0.01055 0.00271
   22.5     0.00000 0.00000 0.00000 0.00000 0.00000 0.00004 0.00045 0.00417 0.01773 0.02538 0.03003 0.01982 0.01759 0.01024 0.00350
   37.5     0.00000 0.00000 0.00000 0.00000 0.00007 0.00046 0.00142 0.01146 0.02680 0.03064 0.03420 0.01904 0.01730 0.00985 0.00420
   52.5     0.00000 0.00000 0.00001 0.00008 0.00053 0.00162 0.00522 0.02901 0.03843 0.03327 0.03324 0.01740 0.01671 0.00977 0.00460
   67.5     0.00000 0.00000 0.00002 0.00009 0.00089 0.00455 0.01187 0.04234 0.03971 0.02967 0.02874 0.01649 0.01639 0.00979 0.00460
   82.5     0.00000 0.00001 0.00001 0.00002 0.00035 0.00276 0.00628 0.01826 0.01545 0.01392 0.01722 0.01657 0.01672 0.00964 0.00421
   97.5     0.00000 0.00000 0.00000 0.00000 0.00008 0.00090 0.00256 0.00196 0.00348 0.00198 0.01196 0.01388 0.00874 0.00352
```

FREQUENCY DIRECTION tables

DIRECTION														
112.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00003	0.00007	0.00011	0.00012	0.00027	0.00298	0.00519	0.00474	0.00272
127.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00030	0.00065	0.00129	0.00203	
142.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00005	0.00026	0.00163	
157.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00006	0.00000	
262.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00002	0.00002	0.00000	0.00000	0.00000	
277.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00004	0.00005	0.00002	0.00000	0.00000	
292.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00004	0.00008	0.00007	0.00001	0.00000	0.00000	
307.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00010	0.00018	0.00008	0.00000	0.00000	
322.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00005	0.00028	0.00076	0.00065	0.00004	0.00000	
337.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00004	0.00036	0.00138	0.00444	0.00691	0.01156	0.00788	0.00162
352.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00035	0.00171	0.00551	0.01245	0.01435	0.01574	0.00972	0.00202

YM DH	GP	LAT	LONG	M/SEC	FROM	U*	HSIG	TSIG	VMD	TPEAK
8402.2718.	1106.	46.250	-48.75	13.03	237.09	0.518	3.95	7.58	51.23	9.83

FREQUENCY
DIRECTION

FREQ	0.04047	0.04440	0.05000	0.05556	0.06111	0.06670	0.07222	0.08056	0.09167	0.10278	0.11667	0.13333	0.15833	0.20833	0.30833
7.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00062	0.00502	0.01162	0.01482	0.01424	0.01483	0.00889	0.00299	
22.5	0.00000	0.00000	0.00000	0.00001	0.00003	0.00025	0.00242	0.01168	0.01791	0.02194	0.01503	0.01479	0.00870	0.00382	
37.5	0.00000	0.00000	0.00001	0.00005	0.00032	0.00102	0.00808	0.02164	0.03046	0.01805	0.01721	0.00940	0.00450		
52.5	0.00000	0.00001	0.00007	0.00044	0.00150	0.00387	0.02083	0.03173	0.02990	0.01911	0.01810	0.01017	0.00484		
67.5	0.00003	0.00009	0.00026	0.00091	0.00303	0.00766	0.02994	0.03578	0.03376	0.01970	0.01858	0.01049	0.00475		
82.5	0.00002	0.00004	0.00010	0.00030	0.00158	0.00426	0.01610	0.02032	0.01905	0.01811	0.01806	0.01016	0.00427		
97.5	0.00000	0.00001	0.00002	0.00006	0.00021	0.00057	0.00327	0.00351	0.02571	0.00711	0.01190	0.01342	0.00889	0.00351	
112.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00004	0.00025	0.00022	0.00041	0.00483	0.00609	0.00541	0.00268	
127.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00001	0.00001	0.00051	0.00219	0.00257	0.00201	
142.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00003	0.00074	0.00166	
262.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00003	0.00002	0.00002	0.00000	0.00000	0.00000	
277.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00007	0.00008	0.00009	0.00002	0.00000	0.00000	
292.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00006	0.00015	0.00002	0.00000	0.00000	
307.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00001	0.00007	0.00007	0.00002	0.00000	0.00000	
322.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00013	0.00043	0.00013	0.00054	0.00184	0.00150	
337.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00002	0.00018	0.00072	0.00231	0.00397	0.00920	0.00719	0.00175	
352.5	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00018	0.00092	0.00303	0.00699	0.01032	0.01335	0.00872	0.00224	

YM DH	GP	LAT	LONG	M/SEC	FROM	U*	HSIG	TSIG	VMD	TPEAK
8402.2800.	1106.	46.250	-48.75	16.32	235.05	0.700	5.08	8.50	59.20	10.80

```
1106    46.250   -48.750
0.25428 0.27897 0.31416 0.34909 0.38397 0.41909 0.45377 0.50617 0.57598 0.64579 0.73306 0.83774 0.99482 1.30898 1.93729
0.01501 0.03491 0.03491 0.03491 0.03491 0.06981 0.06981 0.06981 0.10472 0.10472 0.20944 0.41888 0.83776
84 58 6   10.27 222.17   4.53   8.15   44.84   10.30
0.00000 0.00000 0.00000 0.00000 0.00000 0.00109 0.00875 0.11216 0.69267 1.23871 0.99469 0.66459 0.31770 0.09730 0.01591
0.00000 0.00000 0.00000 0.00000 0.00000 0.00985 0.10177 0.44920 1.46632 1.70815 1.20005 0.72003 0.32171 0.09739 0.01874
0.00000 0.00000 0.00000 0.00109 0.01423 0.10286 0.32390 1.15281 2.05175 1.97187 1.30656 0.72842 0.32409 0.09338 0.02020
0.00000 0.00000 0.00109 0.01751 0.13241 0.41035 1.23652 2.41779 2.55348 1.97516 1.24491 0.69668 0.32190 0.09019 0.01983
0.00000 0.00000 0.00109 0.02955 0.31296 1.16211 2.22137 2.89981 2.35487 1.74372 1.16467 0.68939 0.32117 0.08809 0.01783
0.00000 0.00000 0.00000 0.00875 0.13678 0.66641 1.08442 1.26497 1.27209 1.23324 0.94764 0.61644 0.28524 0.08207 0.01464
0.00000 0.00000 0.00000 0.00000 0.00219 0.03064 0.15210 0.17946 0.18493 0.20080 0.22396 0.30348 0.19970 0.06949 0.01117
0.00000 0.00000 0.00000 0.00000 0.00109 0.00657 0.01094 0.01258 0.01149 0.01368 0.02189 0.04997 0.05234 0.03210 0.00839
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0.00000 0.00000 0.00000 0.00000 0.00018 0.00146 0.00474 0.00383 0.00328 0.00930 0.01806 0.03684 0.03064 0.02663 0.02417
0.00000 0.00000 0.00000 0.00000 0.00000 0.00055 0.00930 0.04979 0.10833 0.11271 0.11052 0.05225 0.07140? 
0.00000 0.00000 0.00000 0.00000 0.00438 0.03994 0.14827 0.28706 0.30348 0.21557 0.07140 0.08763
0.00000 0.00000 0.00109 0.00328 0.03502 0.16797 0.48257 0.60987 0.46288 0.25898 0.08763 0.01245
84 5812 240.13  11.72  46.43   7.79   4.14   9.96
0.00000 0.00000 0.00000 0.00000 0.00000 0.00109 0.00438 0.06183 0.45193 0.97773 0.83785 0.70836 0.32883 0.09620 0.01236
0.00000 0.00000 0.00000 0.00000 0.00000 0.00438 0.04924 0.22816 0.97007 1.38863 1.09536 0.72295 0.32080 0.09338 0.01596
0.00000 0.00000 0.00000 0.00000 0.00766 0.05034 0.15539 0.62702 1.46632 1.67642 1.24747 0.69450 0.31551 0.08982 0.01915
0.00000 0.00000 0.00000 0.00875 0.05800 0.17727 0.57121 1.58724 2.10264 1.82032 1.21245 0.63468 0.30475 0.08909 0.02097
0.00000 0.00000 0.00000 0.00985 0.09739 0.49789 1.29890 2.31657 2.17267 1.62335 1.04831 0.60148 0.29892 0.08927 0.02097
0.00000 0.00000 0.00000 0.00219 0.03830 0.30202 0.68720 0.99307 0.84532 0.76161 0.62811 0.60440 0.30494 0.08791 0.01920
0.00000 0.00000 0.00000 0.00000 0.00875 0.04158 0.09848 0.14007 0.10724 0.10833 0.12694 0.43625 0.25314 0.07970 0.01605
0.00000 0.00000 0.00000 0.00000 0.00000 0.00328 0.00766 0.00985 0.00602 0.00657 0.00985 0.10870 0.09465 0.04322 0.01240
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00036 0.00000 0.00000 0.01094 0.01185 0.01176 0.00926
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0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00073 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00255 0.00036 0.00000 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00657 0.00292 0.00055 0.00000 0.00000 0.00000 0.00000
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.02772 0.02371 0.01185 0.00036 0.00000 0.00000 0.00739
0.00000 0.00000 0.00000 0.00000 0.00219 0.01532 0.07550 0.16195 0.25205 0.21083 0.07186 0.00739 0.00921
0.00219 0.01915 0.09356 0.30147 0.45412 0.52343 0.28706 0.08864

84 5818   13.03 237.09   3.95  7.58  51.23  9.83

0.00000 0.00000 0.00000 0.00000 0.00219 0.03392 0.27466 0.63577 0.54057 0.51941 0.27047 0.08107 0.01363
0.00000 0.00109 0.02736 0.13241 0.63905 0.97992 0.80028 0.54823 0.26974 0.07933 0.01742
0.00547 0.03502 0.11162 0.44208 1.18400 1.40012 1.11105 0.65839 0.31387 0.08572 0.02052
0.04815 0.16414 0.42348 1.13968 1.73606 1.63593 1.18582 0.69705 0.33010 0.09274 0.02207
0.09958 0.33156 0.83821 1.63812 1.95765 1.65289 1.23142 0.71857 0.33886 0.09566 0.02166
0.03283 0.17289 0.46616 0.88089 1.11178 1.04229 0.93779 0.66057 0.32937 0.09265 0.01947
0.00657 0.02298 0.06237 0.17891 0.19204 0.18110 0.25934 0.43406 0.24475 0.08107 0.01600
0.00109 0.00438 0.01368 0.01258 0.01204 0.01496 0.17618 0.11107 0.04933 0.01222
0.00000 0.00000 0.00055 0.00055 0.00036 0.00036 0.01860 0.03994 0.02344 0.00916
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00055 0.00675 0.00757
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
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0.00164 0.00055 0.01109 0.00073 0.00073 0.00000 0.00000 0.00000 0.00000 0.00000
0.00055 0.00383 0.00383 0.00438 0.00073 0.00328 0.00000 0.00000 0.00000 0.00000
0.00328 0.00821 0.00821 0.00383 0.00255 0.00073 0.00000 0.00000 0.00000 0.00000
0.00055 0.00383 0.00255 0.01568 0.01970 0.03356 0.00000 0.00000 0.00000 0.00000
0.00109 0.00711 0.01568 0.03939 0.14481 0.16779 0.01368 0.00000 0.00000 0.00000
0.00985 0.09985 0.08426 0.16779 0.06556 0.00000
0.00109 0.00985 0.05034 0.16578 0.25496 0.37643 0.24347 0.07952 0.01021
0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00798
```

APPENDIX 2.

Sample output from FITHM – File FITH.LOG

```
1106   46.250  -48.750
84   6 58  10.27 222.17  3.583488 0.553582 1.046182 2.790413 0.672281 0.982296  18 0.00121
84  12 58  11.72 240.13  3.493960 0.583178 1.098090 2.332161 0.759597 0.868013  13 0.00128
84  18 58  13.03 237.09  3.251542 0.598952 1.016309 2.361734 0.731093 0.761834   8 0.00088
84   0 59  16.32 235.05  4.304111 0.547314 1.082319 2.814385 0.642081 0.755925  20 0.00190
84   6 59  11.52 255.45  4.351375 0.506286 1.191070 2.756568 0.720991 0.968748  11 0.00273
84  12 59  15.82 277.90  4.850182 0.536354 0.992582 2.396672 0.625110 0.756045   7 0.00085
84  18 59   9.47 303.26  3.991055 0.551305 1.219978 2.779522 0.673700 0.960527   8 0.00077
84   0 60  15.19 307.82  4.006759 0.618117 1.393682 2.387332 0.618345 0.523188  17 0.00106
84   6 60  14.23 322.39  3.872604 0.655051 1.410541 2.018569 0.655284 0.249200  21 0.00113
84  12 60  13.64 334.59  3.435893 0.703150 1.723718 1.375744 1.225273 0.902622  23 0.00199
84  18 60   7.87 342.94  2.321312 0.783562 1.949628 2.027441 0.783562 0.461354  18 0.00755
84   0 61   6.46 341.95  1.259806 0.503554 1.686777 2.030945 0.888862 1.035610  20 0.00107
84   6 61  10.04 182.21  1.700043 0.511690 1.845706 1.456717 0.807962 0.965565  21 0.06077
84  12 61  11.03 190.38  2.655943 0.528814 1.057584 2.212929 0.814339 0.532999  25 0.00650
84  18 61  13.62 178.14  3.606242 0.531027 0.884993 2.100173 0.734464 1.136797  11 0.00361
84   0 62  15.37 181.30  4.438475 0.534183 1.346651 2.462669 0.739918 0.738631  11 0.00043
84   6 62  10.83 213.64  4.345058 0.532228 1.298172 2.378659 0.773763 0.875475  10 0.00108
84  12 62   8.02 279.23  2.781350 0.491082 4.246852 3.480572 0.637503 1.337935  15 0.00562
84  18 62   6.34 236.42  1.906235 0.495106 6.616018 4.057567 0.568175 1.065798  13 0.00344
84   0 63   6.34 252.67  3.525082 0.533936 2.844394 2.597249 0.773724 1.101840   7 0.00280
84   6 63   6.10 225.02  2.996195 0.539982 3.543317 2.553352 0.724932 1.177808   8 0.00398
84  12 63   7.96 185.39  2.902162 0.561663 3.050526 2.482362 0.742995 1.056039  17 0.00262
84  18 63   0.00   0.00  2.653114 0.579166 2.954313 2.412115 0.765073 1.000713   7 0.00415
84   0 64   8.11 280.74  2.744730 0.613550 2.116306 1.807080 0.908759 0.819822  10 0.00090
84   6 64   2.83 264.15  2.593890 0.638087 1.766633 1.383303 0.997841 1.185310  17 0.00453
84  12 64   3.83 229.71  2.425849 0.658418 1.530978 1.260314 1.049990 1.201226  15 0.00397
84  18 64   5.94 110.96  1.993710 0.664812 1.511640 2.906962 0.987481 0.019898 101 0.00259
84   0 65   4.94 115.22  1.384704 0.653142 1.996240 1.100973 1.022500 0.245784  23 0.00303
```

APPENDIX 3.

Sample output from FITDM – File FITDM.LOG

```
1106  46.250  -48.750
84  6 58 10.27 222.17   3.19867 0.52927 1.38189 1.11691 18.22879 2.95403 0.66280 1.48208 0.42350 10.21401 1
 8 4.53 4.32 0.04534
84 12 58 11.72 240.13   2.78524 0.55005 1.46140 1.11907 21.88339 2.69628 0.67679 1.55936 0.43958 12.28419 1
 4 4.14 3.85 0.06736
84 18 58 13.03 237.09   2.70376 0.56691 1.64955 1.09426 15.88770 2.90232 0.73745 1.05189 0.62402  3.20423 1
 4 3.95 3.92 0.03815
84  0 59 16.32 235.05   4.32076 0.53019 1.09610 1.17905 14.05614 2.22127 0.64182 2.23712 0.48071 14.55822 1
 7 5.08 4.83 0.03393
84  6 59 11.52 255.45   3.47392 0.47460 2.06247 1.26486 26.84029 3.79618 0.66247 1.24674 1.12774  3.04537 1
 0 5.09 5.11 0.02970
84 12 59 15.82 277.90   4.39071 0.50335 1.31422 1.38344 13.25027 3.03470 0.68679 1.14796 1.84079  2.63459 1
 1 5.35 5.30 0.07078
84 18 59  9.47 303.26   4.16388 0.54202 1.25600 1.50975 10.12606 2.21738 0.69992 1.51581 2.22143 19.68901 3
 1 4.84 4.69 0.04590
84  0 60 15.19 307.82   4.73663 0.61896 1.39661 2.00124  3.53696 1.55634 0.61900 0.31808 0.86091  2.15060 1
 0 4.61 4.91 0.11858
84  6 60 14.23 322.39   3.47438 0.62030 1.37367 1.84725  6.13607 2.04285 0.71298 2.49995 2.59450 16.16247 3
 7 4.21 4.00 0.06625
84 12 60 13.64 334.59   3.30457 0.70548 2.17039 2.33310  4.34759 1.50780 1.08485 1.47013 2.75037  2.83811
 8 3.65 3.58 0.07942
84 18 60  7.87 342.94   2.74193 0.80171 2.08121 2.55295  3.50079 0.02634 1.52827 15.00176 5.49554 97.29314 2
 2 3.02 2.70 0.12799
84  0 61  6.46 341.95   2.36616 0.86093 0.71826 2.62781  1.33885 0.05402 1.60046 16.05061 5.31763 97.34481 1
 4 2.35 2.27 0.33575
84  6 61 10.04 182.21   1.22454 0.49533 3.56620 0.18287 82.60016 2.05719 0.64485 0.33982 0.53308  4.93210 2
 1 2.31 2.24 0.07983
84 12 61 11.03 190.38   1.99747 0.53234 2.06354 0.18600 37.24171 2.59701 0.74485 0.66912 0.27806  5.20573 1
 9 3.32 3.20 0.05963
84 18 61 13.62 178.14   2.32428 0.54561 1.54488 0.20587 20.60163 3.29150 0.64505 0.78670 0.22811  3.86208
 7 4.17 3.98 0.10045
84  0 62 15.37 181.30   2.13316 0.46641 3.42279 0.90419 18.00110 4.14159 0.58790 1.42120 0.13237 10.33193 1
 3 5.04 4.64 0.05941
84  6 62 10.83 213.64   2.19239 0.46876 4.20722 0.89744 17.44646 3.94506 0.61538 1.50077 0.37329  9.63226
 6 4.90 4.49 0.07445
84 12 62  8.02 279.23   1.17074 0.49004 7.57305 5.65067  0.25629 4.12854 0.54051 1.19778 0.75377 12.28145 2
 2 4.53 4.27 0.09694
84 18 62  6.34 236.42   0.78670 0.48165 8.83409 3.45537  0.17750 4.13981 0.53736 1.48121 0.73525 11.41748 1
 1 4.52 4.20 0.08487
```

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Software was developed to perform a non-linear, least-squares fit of the Ochi and Hubble (1976) six-parameter heave and an extended 10-parameter, directional, wave model to spectra produced by the ODGP hindcast numerical model. The necessary programs RMODEL, FITHM and FITDM were documented including a description of the unit numbers addressed, subroutines used, with appropriate calling sequences, the arrays and variables assigned, and any necessary user interaction required.

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