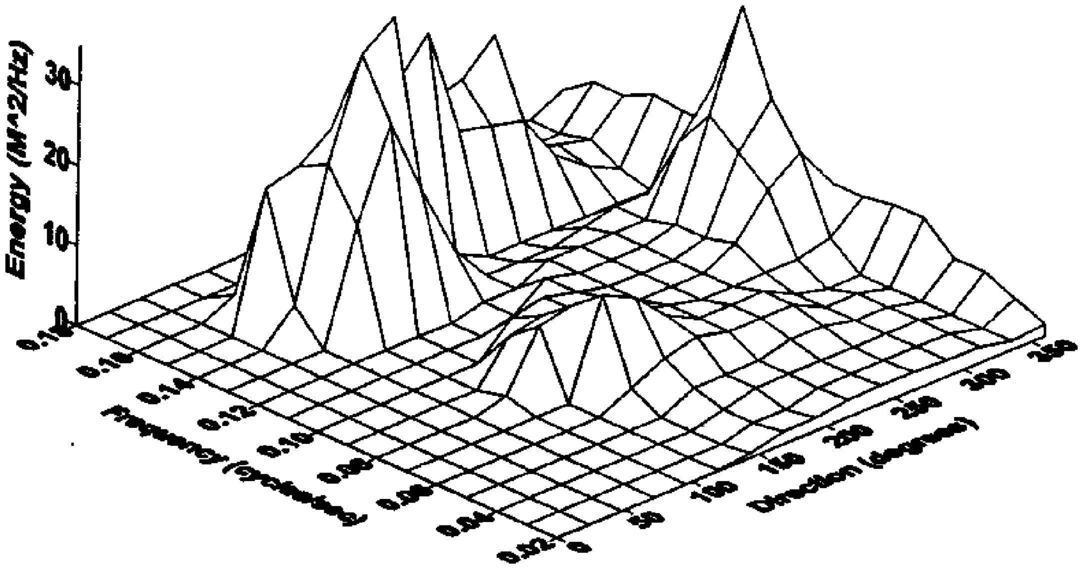
FLORIDA SEA GRANT COLLEGE PROGRAM
R/C-S-34

# The Florida Wave Forecast System



## Florida Sea Grant College Program
## Project R/C-S-34

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# Executive Summary

The Florida Wave Forecast System (FWFS) is designed to provide predictions of directional wave spectra throughout the coastal waters of Florida. The FWFS can be applied with high resolution in the shallow waters of the inner continental shelf and provides a tool for describing and predicting the vulnerability of Florida's coastal zone to storms and beach erosion. The spectral and monochromatic output of the forecast system can be used to set boundary conditions for analytical and numerical models of surf zone and sediment dynamics used by coastal engineers scientists and agencies responsible for managing coastal erosion.

The basis of the FWFS is the discrete spectral wave model known as WAVAD, which was developed over the past decade by Don Resio and associates at the U.S. Army Coastal Engineering Center. The FWFS has been set up on two computational grids. A coarser outer grid provides large regional coverage allowing adequate fetch for wind-generated waves in the western Atlantic Ocean, the Gulf of Mexico, and the Carribbean Ocean. An inner, finer grid provides for the details of local wind wave genration and propagation of wave energy into shallow coastal waters. The FWFS is driven by forecast winds from the National Weather Service, which are available on a NOAA ftp server. Predicted and gridded wind data are available in forecasts of up to 72 hours. The FWFS can also be used in the hindcast mode by using historical records of wind velocity or atmospheric pressure.

The FWFS is easily transferable to both PC and workstation environments. Requirements to run the forecast scheme in the PC enviroment include a minimum of a 486 microprocessor, adequate disk space for storing model input/output, and a high-speed connection to the Interner for downloading forecast winds. The wave forecast system can also be readily transfered to the national or international level by generating computational grids in the areas of interest, and acquiring the appropriate wind or atmospheric pressure data to drive the model. No changes in the model code are required for application to other geographic areas. The final report of this project is designed as a manual and user's guide to model setup and operation.

# Acknowledgments

The Florida College Sea Grant Program is thanked for their financial support and encouragement for this project. The Florida Institute of Technology provided matching support and computing facilites to develop the Florida Wave Forecast System. Technical assistance was provided by Howard Lee, a long-time user of the WAVAD model. Jessica Schauer and Jennifer Resio assisted with digitizing topograpahic data for model grid generation. Michelle Peters assisted with compilation of the final report.

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## 1.0 Introduction and Goals of the Project

Directional wave spectra have been measured at various sites in Florida's shallow coastal waters for more than twenty years. Analysis of wave climate at a few discrete locations in 10 meters of water or less have provided useful, but limited analyses of wave climate. These data and analyses are generally used for site specific coastal engineering applications including beach nourishment, design of shore protection structures, and setting of boundary conditions for analytical, physical, or numerical models of wave-driven hydrodynamics and sediment transport. The overall goal of the Florida Wave Forecast System (FWFS) is to use the well-tested and widely accepted discrete spectral wave model known as WAVAD (Resio and Perrie, 1989) to develop a regional and state-wide tool for forecasting the specral wave field in coastal waters. Accurate wave forecasts that are continuous in time and space will allow coastal zone management, planning for storm response, and associated coastal engineering activities to be conducted on a regional basis that considers the coastal zone as a system rather than small individual components.

A second part of the overall goal of this project is to provide a wave forecast scheme that is base user friendly application of the WAVAD model that can be easily implemented in a PC computing environment as well as the multitasking workstation environment. An additional goal is to provide a modeling scheme that can also be applied in the hindcast mode as an aid in assessing long-term wave and storm-driven sediment budgets that can be used for managing coastal erosion on a long-term planning horizon.

## 2.0 Project Objectives

Specific objectives of the Florida Wave Forecast System include:

- To provide predictions of wave spectra throughout Florida's coastal waters that can be conveniently accomplished in a desk-top computing environment.
- To provide a tool for characterizing coastal wave climates and improving our understanding of vulnerability to storms and beach erosion on a state-wide basis
- To provide a predictive tool in a "turn-key" format that can be easily transferred to, and used by state an local management agencies and used by the academic community for applied and basic research.

The major goals and objectives of this project are concerned with applicability of the FWFS to all of Florida's coastal waters. Figure 1 illustrates the coarser of two computational grids used in the Florida Wave Forecast System and shows the area of coverage included in the modeling system. The combination of a coarser "outer" grid and finer "inner" grid ensures that that details of Florida's coastal waters are well represented in the modeling scheme and that a large enough area is included to model wind forecing required to accurately predict the coastal wave field.

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Figure 1. Configuration of the Florida Wave Forecast System on the regional grid of the Atlantic Ocean and Gulf of Mexico. Zeros indicate land areas and ones indicate active water cells in the computational grid of the model.

## 3.0 Project Structure

The Florida PC Wave Forecasting System is based on an application of the spectral wave model known as WAVAD, which is a discrete spectral model developed by Resio (1982, 1989,1990). The wave model uses input wind fields as the primary generating forece for deep water waves. The numerical formulation of the WAVAD model also includes algorithms for propagating wave energy away from the generating area. The WAVAD model is based on an $f^{-4}$ equilibrium range, and is consistent with energy conservation in the equilibrium range similar to that calculated from the complete Boltzmann integrals (Resio, 1989). The fetch-growth characteristics simulated by the model are similar to spectra measured during the Joint North Sea Wave Project (JONSWAP spectra), which indicated that wave growth along a fetch is governed by a self-similar process (Resio, 1981).

In the FWFS, WAVAD is implemented on two computational grids the coarser of which includes the Gulf of Mexico, the Atlantic Ocean off the southeastern U.S. and a portion of the Carribbean Ocean. The second grid includes a finer 15-km grid cell spacing and is confined to the coastal ocean surrounding the Florida Peninsula. The computational grid defines the topographic and geographic features of the model domain. In order to operate the model in wind velocity data gridded at the same geographic spacing is required as input to the model. The model can be instructed to update the predicted wave spectra in accordance with changes in the input wind field. Therefore, as long as the wind field can be updated the model can be run indefinitely in a time-marching manner. Forecasted wind data from the National Weather Service allows the Florida Wave Forecasting System to forecast the wave field for up to 48 hours in the future. The model can also be run in a now-cast or hindcast mode depending on the type of wind forcing used.

The Florida Wave Forecast System was developed in this project by digitizing bottom topography and land configurations from NOAA bathymetric charts and acquiring wind data from a NOAA ftp site over the Internet, and gridding the wind data over the model domain. All information required to perform of wave forecast is included in a main model input file, small unformatted input files describethe boundary conditions around the perimeter of the model grid, and input files listing the time varying wind field.

Methodology is explained in more detail in the following sections, which describes model theory ( Section 4) structure of the FORTRAN code of WAVAD, as well as descriptions of model input and output files (Section 5). To facilltate the use of the Florida Wave Forecast System a users guide is included in Appendix 1 of this report. The FWFS Users Guide provides a description of the main input file, other input files required by the system, and an explanation of model output files. The final section of this report (Section 6) describes model output from the FWFS. Appendix 1 contains examples of model from a forecast run for the first eight days of 1996.

## 4.0 Theoretical Basis of Wave Forecasting

The theoretical basis of WAVAD, and thus the Florida Wave Forecast System is described in a series of papers by Resio (1981, 1987) and Resio and Vincent (1982), and Resio and Perrie (1989). The discrete spectral model WAVAD was developed and refined over more than a decade by considering momentum fluxes within wave spectra, related equilibrium range characteristics, and the observed growth rates of wind driven waves (Resio and Perrie 1989). It is evident that wind-wave spectra have a very sharp cutoff at frequencies below the peak on the forward face, and have a somewhat more gently sloped rear face. The limiting shape geometry of the forward face of wind wave spectra is assumed to be constrained by breaking of the steepest members. Arguments can be made suggesting that the spectral energy density of the high frequency rear face of wind wave spectra is proportional to $1/\omega^5$ or $\omega^{-5}$. More recent works have shown that the rear face of wind wave spectra do not follow a strict $\omega^{-5}$ law (Forristall, 1981; Kahma, 1981, ;Resio, 1989).

Since theoretical and empirical evidence for a $\tilde{\omega}^{-4}$ power law is now generally accepted the present formulation for predicting wave spectra in WAVAD is now based on a $f^{-4}$ law. Conceptually the WAVAD formulation consists of three major components or concepts. Firstly, nonlinear wave-wave interactions are considered primarily responsible for transfer of energy to the forward face of the spectrum. The assumption of the $f^{-4}$ power law in this component of the model leads to a distinctly different pattern of wave growth than a $f^{-5}$ law. By these nonlinear interactions energy cascades through the spectrum from low to high frequencies. Kitaigorodskii states the form of this process as

$$\phi(f) \approx \epsilon_o^{1/3}\ g\tilde{\omega}^{-4} \qquad 1$$

where is the energy flux via the cascade process from a region near $f = 0$ toward a region near $f = \infty$. It is assumed that the spectrum adjusts to a form such that energy flux is constant. Another major component of the WAVAD is the wind source term, which must describe a source of energy and momentum to balance the net flux of momentum and energy out of the midrange frequencies of the spectrum. Finally, representations of nonlinear wave-wave interaction and energy source must be formulated in the model to provide for energy transfer into and out of an element in a directional spectrum. A general equation for the evolution of spectra for surface waves can therefore be written as

$$\frac{\partial E(f,\theta)}{\partial t} = c_g(f) \cdot \nabla E(f,\theta) + \sum S_i \qquad 2$$

where $\partial E(f,\theta)$ is the energy density at frequency $f$ and propagation direction $\theta$, $c_g$ is the group velocity vector for a particular frequency - direction element, and Si is an energy source. Several works examine energy balances among various source/sink mechanisims under certain conditions (Komen,1984, Hasselman et al, 1985, Hasselman and Hasselman, 1985. For an $f^{-4}$ equilibrium range spectrum, a dimensionally consistent spectrum is of the form

$$E(f,\theta) = \frac{\alpha 1 V f^{-4}}{(2\pi)3}\ \psi 1\left(\frac{f}{fm}\right) \Lambda \left(\theta-\theta o, \quad \frac{f}{fm}\right) \qquad 3$$

where $\alpha$ is a dimensionless equilibrium range coefficient, g is acceleration due to gravity, $fm$ is the frequency of the spectral peak, $\psi$ is a dimensionless shape function, which depends on the shape of the forward face of the wave spectrum, and $\Lambda$ describes the angular distribution of energy around the mean angle $\theta$.

Hasseleman (1962) established the theoretical basis for nonlinear interactions among various waves in a spectrum The governing equations for this process can be found in Hasselman (1962) and Webb (1978). Tracy and Resio (1982 and Resio (1987) further simplified the governing equations for numerical integration by implementing it on a polar grid having geometrically spaced increments along the radials. Consistent with the findings of Kitaigorodskii (1983), Resio (1987) showed that a constant energy flux condition as required in a dynamic equilibrium could only exist in deep water for the case of an $f^{-4}$ spectrum.

Wind is the only likely source of momentum to balance the net flux of momentum out of the midrange frequencies (Resio,1989). Therefore, a reasonable approximation to the wind momentum source in the midrange frequencies is

$$\int_{fm}^{zfm} S'_w(f)df = \frac{1\ \partial Mo}{P_o\ \partial t} = \frac{M\ 1\ u*2}{2p_o\quad g} \qquad 4$$

where S'w is the source function for wind-to wave momentum transfer z is a dimensionless constant , and $u_*$ is the friction velocity for wind. For a wind source function in terms of rates of energy transfer Eq. 4 can be transformed into

$$\int_{fm}^{zfm} S'_w(f)df = \frac{B1\ M1}{2\ P_o} = \frac{u_*^2\ cm}{g} \qquad 5$$

where $S'_w(f)$ is the source function and B1 is a dimensionless constant. Wind source terms are conventionally of the form

$$S_w(f) = BE(f)$$

where B has the dimensions time$^{-1}$. Recently Philips (1985) suggested a new form for the wind source function that is consistent with an $f^{-4}$ equilibrium range. This form as modified by Resio (1989) can be stated as

$$\int S_w(f)df = \frac{\alpha u^{*2}}{g}\ c_m \qquad 6$$

which is consistent with Eq. 5. Therefore in WAVAD the wind source term is considered to be represented by Eq. 6. The presence of $u^{*2}$ in Equations 5 and 6 is consistent in a physical context since the transfer of momentum due to surface stress is expected to be of this form.

## 4.1 Modeling the Evolution of an $f^{-4}$ spectrum

The highly nonlinear shape of the source function near spectral peak makes it difficult to represent this process over a long time step. Resio (1989) demonstrated that different results can be obtained for the evolution of a spectrum over a fixed time interval, depending on the time step used in the integration of the governing equation. To avoid this distortion, the location of the nonlinear source pattern must be allowed to shift over the time interval. Hasselmann et a.l (1976) showed that the characteristic relaxation time for spectral components in the quilibrium range is about 15 minutes. Thus to model perturbation of equilibrium range energies away from their equilibrium values a time step considerably less than 15 minutes is required. In the use of the WAVAD model it is common for time steps of 4 minutes to be required for accurately representing spectral evolution. Over any finite time step, the peak frequency will shift and with it the location of the net wave-wave interaction energy transfers. Neglecting, swell decay, the source function can be parameterized by estimating the evolution of the spectral peak over a time step as

$$E(f)^{i+1} = E(f)^{i} + \int_{ti}^{ti+\Delta t} \mathrm{Sinl}\,(f) + \mathrm{Sin}\,(f)dt \qquad 7$$

where ti is the time at time step i.

In integrated form over time step Δt, the frequency at the spectral peak can be represented as

$$f\mathrm{m}^{i+1} = \left[ (f\mathrm{m}^{i})^{-2} + 1.8\,\Lambda\, u^{*-4/3}\Delta t \right]^{-3/7} \qquad 8$$

The functional form of Eq. 7 is very stable computationally, since no dependence of $f$m is found in the second term on the RHS of this equation. This means that the same computational result can be obtained independent of time step chosen (Resio and Perrie, 1989). It is straightforward to see how Eq. 7 cab be used to infer a one dimensional (nondirectional) spectrum. However it is not obvious how the directional distributions of energy can be determined. For the one-dimensional energy density Resio and Perrie obtained a parametric representation of the form

$$E(f)\mathrm{i} = \alpha'*(\mathrm{u}2*\mathrm{cm})1/3\ g\, f^{-4}\, \psi\left(f/f_{m}, \mathrm{u/cm}\right) \qquad 9$$

where $\psi$ is a shape function that includes dependence on $f/f_m$, u/cm. In the WAVAD model directional characteristics are approximated by considering the total wind input over a time step and recognizing that the wave-wave interaction cannot alter the mean direction since they are conservative (Resio and Perrie, 1989). Hence, the mean wave direction at the end of a time step can be estimated by the wind speed and direction over a time step and the inital directional spectrum.

In summary the WAVAD model on which the Florida Forecast System is based uses concepts of surface gravity wave dynamics consistent with an experimentally validated $f^{-4}$ equilibrium range (Donelan et al, 1985). The observed fetch-growth behavior in wind waves is consistent with the hypothesis that a constant portion of wind-to-water momentum flux is retained by the wave field. Using this hypothesis as a point of departure, along with some scaling relationships in the wave-wave interaction integral, WAVAD is based on the assumption that an $f^{-4}$ equilibrium range is compatible with the balance of energy fluxes though a wave spectrum. In the operational mode the WAVAD model a number of empirical constants in the $f^{-4}$ -based WAVAD model must be set. Evaluation of these constants provides calibration for the model. A discussion of how the empirical constants are set in the model can be found in Resio and Perrie (1989).

## 5.0 Model Set-up and Operation

Set up procedures for the Florida Wave Forecast System are described in general in the following sections. Appendix I, the FWFS user's guide that describes how to steer the FWFS through a production run by specifying the dimensions of the computational grid and by setting certain parameters to control model input and model output.

## 5.1 Fortran Programs

The setup and operation of the PC wave model requires several FORTRAN programs and input files that specify model parameters and input data. Figure 2 summarizes the overall structure of the WAVAD model on which the wave forecasting system is based. Table 1 lists the Fortran programs that are used in the typical application of WAVAD. Program WVSRF.FOR can be considered the main driver program that begins executing at the beginning of a model run. WVSRF begins by including Programs FLXSRF.FOR and DPROP.FOR as subroutines in the driver program using an INCLUDE statement. FLXSRF is the discrete spectral model that simulates the generation of spectral wave energy according to the theory and parameters described in section 4.0 of this report. Program DPROP specifies the propagation of spectral wave energy generated by FLXSRF. No other executable programs are required to run the wave model.

There are several utility programs provided with the FWFS, which are discussed in more detail the following section where appropriate. Program EXTEND.FOR is a geostrophic wind model that generates a predicted wind field from gridded pressure data. Program IPR.FOR is used to interpolate pressure data onto a grid conforming the Florida Wave Forecast System . Program IWN.FOR is designed to read and write gridded wind data to be used by the wave model.

Table 1. FORTRAN programs inlcuded in the FWFS

| FILE NAME | FILE DESCRIPTION |
|---|---|
| WVSRF.FOR | main program |
| FLXSRF.FOR | discrete spectral wave energy model |
| DPROP.FOR | calculation for spectral wave energy propagation |
| EXTEND.FOR | geostrophic wind model driven by gridded pressure data |
| IWN.FOR | program to read and write wind data |
| UTIL3D.FOR | utility program to write wave data for 3-D plotting |
| IPR.FOR | utility program to interpolate pressure data |

## 5.2 Model Input

The FWFS requires several input files that are read during a model run. Table 2 lists all of the input files required to run the wave model for the Florida application The main input file is called OPTIONS, which specifies the input and output of the model, as well as serving as the computational grid. The User's Guide in Appendix I defines the meaning of the fields in the OPTIONS and also includes an example of one of the OPTIONS files provided with the FWFS.

Table 2. Input files to the Florida Wave Forecast System

| FILE NAME | FILE DESCRIPTION |
|---|---|
| OPTIONS.DAT | main input file designed to guide model input/output |
| WINDS.DAT | gridded wind data used to drive the PC wave model |
| WRMSTR.BN | Binary file containing data for warm start of PC wave model |
| BNDIN.BN | Binary file containing boundary data for PC wave model |
| EXTEND.INP | input file to set parameters for Program EXTEND.FOR |
| PRESS.DAT | gridded pressure data read by Program EXTEND.FOR |

The FWFS includes four versions of the OPTIONS main input file (Table 2). OPTIONS.60c is the main input file to guide the model from a cold start over a coarse 60 km cartesian grid, whereas OPTION.60w guides the model over the coarser grid, but from a warm start. In the warm start case, the model run is the continuation of an earlier run from which certain data have been saved in order to restart the model for a "warm" start. The main input file provides the option of whether to save restart information or not. Files containing the data for a warm start are called WRMSTS.BN and are written in binary format. Among the sample input data for the four-day simulation provided with the FWFS, the files called day1.rs1, day2.rs1 are the binary files specifying a warms start on the coarser grid. For use in the example run these files must be renamed WRMSTR.BN.

Similar to the OPTIONS input files that provide information for a model run over a coarse grid, OPTIONS.15 input files specify operation of the FWFS over a finer inner computational grid (Fig 2). The inner grid is Cartesian having a uniform cell size of 15 km. In order to operate the model in the finer grid, boundary information must be specified at a series of points where the coarser outer grid and finer inner grid connect. Again, the OPTIONS main input files specifies whether these boundary data are read in and whether the boundary file is written at the end of a model run on the coarser grid. The boundary file is written in binary format for convenience and is read in as BNDIN.BN by the main driver program if required by OPTIONS. Among the four days of example output provided with the FWFS system a boundary file is written at the end of each day (i.e. day1.bo1). In order to run the example provided with this report on the inner grid the boundary files must be renamed to BNDIN.BN

Other major input files that are used by the FWFS are the files specifying the wind field interpolated onto the computational grid. The WINDS.DAT files contain wind speed data in knots and wind direction in mathematical format. Wind directionis the direction to which the wind is blowing counter clockwise from east. The wind data is gridded in the same format as the computational grid listed in the main input file OPTIONS. Wind speed and direction are listed in separate matrices in the WINDS.DAT corresponding to the rows and columns of cells in the computational grid. An example of a portion of the wind data file is given in the model use'rs guide (Appendix 1).

The geostrophic wind model EXTEND.FOR can be used to provide hindcasted wind field from atmospheric pressure data. This means that the FWFS can also be used to make long-term wave hindcasts from pressure data obtained from weather maps. An example pressure data set in file PRESSIN.5 is provided that can be read by EXTEND.FOR to generate 5 days of predicted wind data to drive the wave model.

The wind data file must be read from a forecasted wind field if the FWFS is run in a forecast mode. Appendix II provides a description of the downloading procedure used to acquire gridded binary (GRIB) wind data from a server maintained by the National Oceanic and Atmospheric Administration (NOAA). Forecast wind data for periods of up to three days are in a public directory and can be downloaded and expanded under both PC and UNIX systems. The NOAA server provides free software for decoding and unpacking GRIB wind data. Once the forecast wind data are available, they must be placed in the proper format for the Florida computational grid. Utility programs for reading and writing wind data for the FWFS grid can be found in the file WINDIO.FOR. The WINDS.DAT file for model run is created from the forecasted wind data using Program IWN.FOR, which reads gridded and wind data obtained from NOAA (see Appendix 2) and interpolates the forecast data onto the FWFS grid.

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Figure 3. Configuration of the Florida Wave Forecast System on the inner computation grid including the coastal waters surrounding Florida.

## 6.0 Model Output

The software package included with the FWFS final reports includes examples of model output from a run of the model beginning. On 1 January, 1996. In addition, the users guide in Appendix 1 provides an explanation of model output files and a description of the data fields in each type of output file. Table 3 lists the major output file provided by the model.

## 6.1 Predicted Wave Data

The FWFS provides several file types to describe the forecasted wave field. (Table 3). ONELNS.DAT contains a one-dimensional summary of monochromatic wave statistics for selected cells in the model grid. The particular cells and time interval for which ONELNS.DAT provides data are set in the main input file OPTIONS.DAT. The monochromatic data includes date/time, cell location, significant wave height, swell height, period of the average forecast wave and swell, swell angle, and wind speed and direction in the specified swell. The format of ONELNS.DAT and an examples of this type of output file is included in the model users guide.

Table 3. Output file from the Florida Wave Forecast System

| FILE NAME | FILE DESCRIPTION |
|---|---|
| ONELNS.DAT | summary of wave/wind parameters |
| ONED.DAT | one-dimensional wave spectra |
| TWOD.DAT | wave energy by frequency and direction |
| WAVES.DAT | wave direction and height by grid cell |
| MAXFILE.DAT | maximum height/direction for model run |
| NXTSTR.BN | data for a warm start of the model |
| BNDOUT.BN | boundary data for run on nested grid |

ONED.DAT lists one-dimensional spectra for selected output points in the model grid. This file provides the predicted energy density for each frequency bin specified by the wave model. Two-dimensional spectra for selected output points are written in output file TWOD.DAT. This file type provided predicted wave data according to frequency and direction. The initial record in this file provides summary data for a specified location within the model domain and is followed by a data matrix that describes wave data according to energy density, frequency and direction. Figure 3 shows the result of a predicted two-dimensional spectra for a cell located seaward of Cape Canaveral during the second day of a forecast model run. The FWFS Users guide (Appendix 1) explains the format of TWOD.DAT and provides an example of two-dimensional model output.

WAVES.DAT can be considered the main output file of the forecast model. This output file contains wave height, period, and direction fields for the entire model grid. The fields are written in blocks including three geographically oriented matrices containing wave heights, wave periods, and wave directions. For long forecasts or hindcasts this output file can become very large and therefore, some care should be taken during the model setup so that computer mass storage is not overwhelmed. The model user's guide (Appendix 1) contains an explanation of the WAVES.DAT file and a partial listing of the file.

MAXFILE.DAT provides a listing of the maximum predicted wave height for a model run, along with the associated period and direction This file is similar to WAVES.DAT, but contains only one set of fields. The first data matrix lists the maximum wave height at every point in the model grid, the second matrix lists the periods and direction. The model users guide in Appendix 1 provide a more detailed description of the MAXFILE.DAT format.

## 6.2 Binary Files

NXTSTR.BN is an output file produced to provide data for a warm start of the next model run. This file type is used in conjunction with the model grids designed for a warm start of the FWFS (OPTIONS.60w and OPTIONS.15w) and is unformatted (binary). File BNDOUT.BN includes boundary data for the next model run on a finer nested grid. Therefore this file becomes BNDIN.BN for a model run on one of the finer-meshed grids provided with the Florida PCWFS (OPTIONS.15c/w). Output file FRCST.RST is designed for a warm start for a model forecast run and should be specified in the model setup only when the model is being used in the forecast mode.

## 7.0 Examples of Predictions of the Directional Wave Spectrum

Figure 4 shows the predicted spectral wave field off the southeast shoreline of Cape Canaveral at the beginning of the third day of January 1996. The predicted spectral wave field shows moderate to low wave energy at the low end of the frquency spectrum of moving to the north west toward the Cape. Figure 5 shows the spectral wave field at the same location 24 hour later. The predicted wave spectrum at Midnight on 04 January, 1996 is similar, except reduced in overall energy. By 05 January the predicted wave spectrum evolved to include peak energy a higher frequency (equivalent to approximately 9 second period).

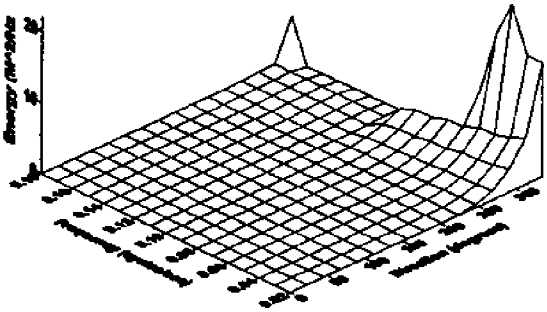

Figure 4. Predicted directional wave spectrum at midnight on 03 January, 1996.

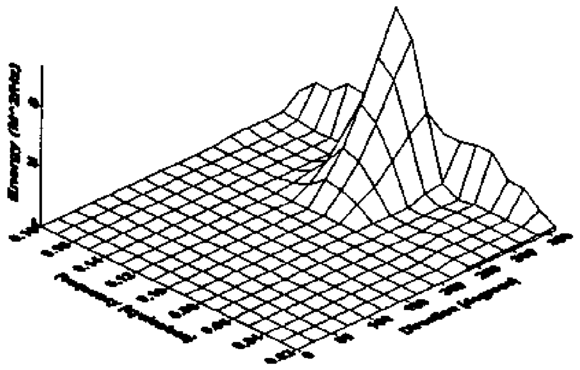

Figure 5. Predicted directional wave spectrum at midnight on 04 January, 1996.

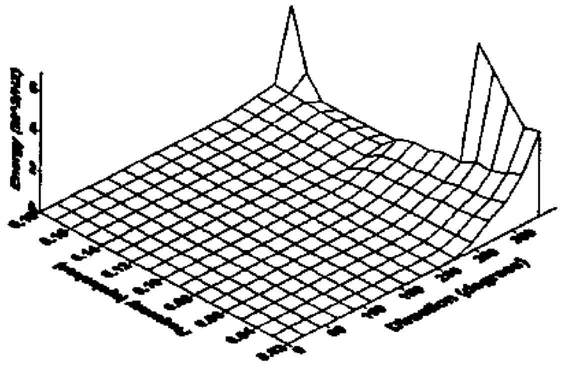

Figure 6. Predicted directional wave spectrum at midnight 05 January 1996.

The predicted directional spread of energy is wider showing wave energy moving to the west to northwest. By midnight 07 January the predicted directional spectrum broadened to include a wide range of frequencies, but at very low energy (Fig 7). Peak energy occurred at frequency of 0.15 cycles/sec (approximate period of 6.6 seconds). The final predicted spectrum presented here is at the same location to the southeast of Cape Canaveral at midnight 09 January. In this spectrum, wave energy is concentrated at frequencies equivalent to perods of 7 to 10 seconds and in directional bins ranging from 75 to 260 degrees. The visual intepretation of this spectrum would be choppy seas and no swell.

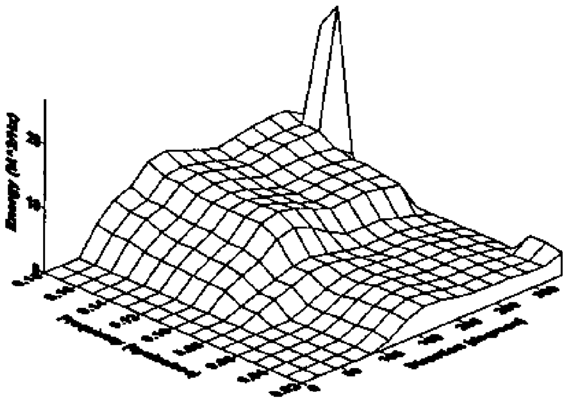

Figure 7. Predicted directional wave spectrum at midnight 07 January, 1996

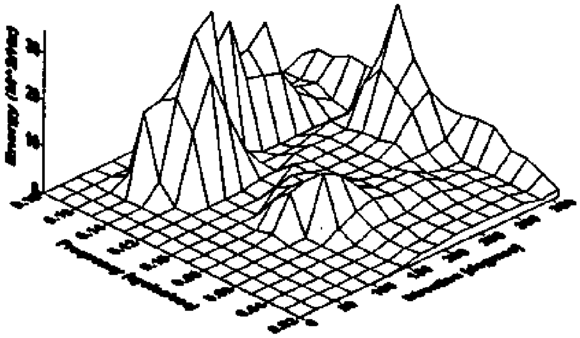

Figure 8. Predicted directional wave spectrum at midnight 09 January, 1996

## 8.0 Support for Model Setup and Operation

The users guide for the Florida Wave Forecast System (Appendix 1) provides detailed instructions on how to setup and run the system The forecast modeling scheme is designed to be run on a coarser grid first and secondly on an inner, finer grid that provides more spatial detail in the Florida coastal zone. Instructions on how to find and decode gridded wind data used to operate the model in the forecast mode can be found in Appendix 2. Computing hardware required to run the model in the PC environment includes at a minimum a 486-based system having 8 megabytes of RAM. The wind data is most conveniently acquired using a workstation environment, however the PC environment can be used if adequate speed (486-chip at a minimum) and disk storage are available along with a high speed link to the Internet. A complete set of software and set of example input/output files are available from the Florida Sea Grant Office, as well as from Gary A. Zarillo at the Florida Institute of Technology (zarillo@fit.edu). Dr. Zarillo can be contacted directly concerning specific questions concerning model setup and operation.

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# APPENDIX 1

## Florida Wave Forecast System Users Guide

## “OPTIONS. DAT” INPUT SPECIFICATIONS Fortran unit 20

Logical Record 1

| | | |
|---|---|---|
| Field 1 | NX | The number of elements in the X dimension of the grid. |
| Field 2 | NY | The number of elements in the Y dimension of the grid. |
| Field 3 | NANG | The number of angles in the simulation. **Always 16!** |
| Field 4 | NFRQ | The number of frequencies in simulation. |
| Field 5 | DL | The distance between adjacent grid points in kilometers |
| Field 6 | DT | The time-step in seconds. |
| Field 7 | MSTA | The number of special output points. |
| Field 8 | IFTYPE | Frequency input type.<br>IFTYPE = 0 Frequencies are read in (smallest to largest)<br>IFTYPE = 1 Read in first frequency and geometeric factor (L). All other frequencies are computed by F*n* = F1 * L ** (*n* - 1), where *n* is the frequency counter and F1 is the lowest frequency. |
| Field 9 | INPLEV | Option for input level of winds:<br>INPLEV = 0 Winds at 10 metres.<br>INPLEV = 1 Winds at 20 metres. |
| Field 10 | NSSPTS | Number of sub-scale features (usually 0). |
| Field 11 | IHEM | Hemisphere selector<br>IHEM = 0 Northern Hemisphere<br>IHEM = 1 Southern Hemisphere |
| Field 12 | NHRSAV | The time, in hours, from the start of the run at which restart information will be saved. Used in forecast mode only. If NHRSAV = 0, then no restart data will be saved. |

Logical record 2

| | | |
|---|---|---|
| Field 1 | NSTR | Cold start/warm start selector. Determines whether data from a previous run is read to start present run (called a warm start).<br>NSTR = 0 Cold start; no restart data is saved<br>NSTR = 1 Cold start; restart data is saved<br>NSTR = 2 Warm start; no restart data is saved<br>NSTR = 3 Warm start; save restart data<br>For the FIT setup, use **NHRSAV** to save restart data nd **NSTR = 2** to read warm start data. NHRSAV saves data at a specified time. **NSTR = 1 *or* 3** saves data at the end of the run. |
| Field 2 | NORD | Determines whether or not wind input data is read. This option is used for testing purposes only and should always be set to 0.<br>NORD = 0 Read wind input.<br>NORD = 1 Do not read wind input. |
| Field 3 | NTMS | Number of timesteps between calls to special output routines. **NTMS** is equal to the desired length of time between calls to output routines divided by the length of time steps. For example, if the time step is 900 seconds and output is desired on 12 hour increments, then **NTMS** is 48.<br>12 * 3600.0 = 43200<br>43200 / 900 = 48 |
| Field 4 | NHR | The number of hours between wind inputs. |
| Field 5 | MXHR | Maximum number of wind inputs to process; used in testing to limit the length of a run. |

Field 6 IBND Boundary data optionto be used in nesting WAVAD runs.

IBND = 0 No boundary dat read or written. This option would be used in a single grid run where there are no nested grids.
IBND = 1 Boundary data written, none read in. This option would be used in the ouer or first grid in a nested run.
IBND = 2 Boundary data read, none written. This option would used in the innermost (or last) grid in a nested run.
IBND = 3 Boundary data read in and written. This option would be used in the intermediate grids in a multiple nested run.

Field 7 IWRAP Global wrap-around option.

IWRAP = 0 No wrap-around.
IWRAP = 1 Wrap-around.

Field 8 ISTDEP Depth read option.

ISTDEP = 0 Read depths from OPTIONS.DAT
ISTDEP = 1 Set all depths to **DEEP**. No depth data in OPTIONS.DAT.

Field 9 IKOUTL Output level flag.

IKOUTL = 1 Write only one-line summaries (ONELNS.DAT).
IKOUTL = 2 Write one-line summaries and one-dimensional spectra (ONED.DAT).
IKOUTL = 3 Write one-line summaries, one-dimensional spectra, and two-dimensional spectra (TWOD.DAT).
IKOUTL = 4 Write one-line summaries and wave height period and direction fields (WAVES.DAT).
IKOUTL = 5 Write one-line summaries, one-dimensional spectra, and WAVES.DAT.
IKOUTL = 6 Write everything.

### Logical record 3

| | | |
|---|---|---|
| Field 1 | DLAT | Latitude increment in degrees. |
| Field 2 | XLAT | Southernmost latitude in degrees (negative in the Southern Hemisphere). |
| Field 3 | ICURV | Curvature option. |

| | |
|---|---|
| ICURV = 0 | No curvature effects included in propagation. |
| ICURV = 1 | Include curvature effects in propagation. |

### Logical record 4

If **IFTYPE = 0,**

| | |
|---|---|
| then All Fields: (FREQ(K), K=1, **NFRQ**) | **NFRQ** frequencies from smallest to largest (Note: Can be more than one physical record). |

*or* if **IFTYPE = 1,**

| | | |
|---|---|---|
| Field 1 | FZRO | First frequency |
| Field 2 | PWR | Power for geometrically spaced frequencies (See **IFTYPE** above). |

### Logical record 5 (Optional: if **MSTA > 0**)

| | | |
|---|---|---|
| All Fields: | (IOUT(K),JOUT(K),K=1,MSTA) | I and J locations for special output points. (Note: Can be more than physical record). |

### Logical record 6

| | | |
|---|---|---|
| Field 1 | IDFRST | Date-time code for limiting first processing hour. |
| Field 2 | IDLAST | Date-time code for limiting last processing hour. |
| Field 3 | IDBND1 | Date-time code for limiting first hour when boundary data is written. |
| Field 4 | IDBND2 | Date-time code for limiting last hour when bouondary data is written. |

Logical record 7

| | | |
|---|---|---|
| Field 1 | INSSPS | I-coordinate for sub-scale feature. |
| Field 2 | JNSSPS | J-coordinate for sub-scale feature. |
| Field 3 | BLKX | X-direction blocking coefficient ranging from 0 to 1 where 1 represents total blockage and 0 represents no blockage. |
| Field 4 | BLKY | Y-direction blocking coefficient. |

Logical record 8

All Fields: Geographically oriented depth matrix for all grid points (in metres).

Logical record 9

All Fields: Geographically oriented land-sea matrix for all grid points.
Format = (80i1)

0 = Land or perimeter point
1 = Water point
2 = Extrapolated boundary point at leading edge
3 = Input boundary point
4 = Interpolated boundary point
5 = Extrapolated obundary point at trailing edge.
(Number of physical records equals the number of rows in the grid.)

Logical record 10 (Optional: If IBND > 0)

If IBND = 1 Output boundary data for next grid, but no boundary data input form previous run. (First step in series of nested grid runs).

| | |
|---|---|
| NBPO | Number of output boundary points. |
| (IBPO(K),K=1,NBPO) | Ordered I-locations for boundary output. |
| (JBPO(K),k=1,NBPO) | Ordered J-locations for boundary output. |

If IBND =2 No boundary data output, but boundary data is coming in from an outer grid. (Last step in a series of nested grid runs.)

| | | |
|---|---|---|
| Field 1 | ILS | Starting I-position for boundary data string. |
| Field 2 | JLS | Starting J-position for boundary data string. |

|  |  |
|---|---|
| If IBND =3 | Output boundary data for next grid and obundary data input from previous run. (Intermediate steps in series of nested grid runs.) |
| NBPO | Number of output boundary points. |
| (IBPO(K),K=1,NBPO) | Ordered I-locations for boundary output. |
| (JBPO(K),K=1,NBPO) | Ordered J-locations for boundary output. |
| ILS,JLS | Starting I-, J-coordinates of starting point in a boundary string. |

Logical record 11

|  |  |  |
|---|---|---|
| Field 1 | IUWS | Wind speed for test case (knots) |
| Field 2 | IUDIR | Wind direction category defined as integer catefory equal to (WIND_ANGLE) / 5.0 + 1.5 |
| Field 3 | ISHFT | Option to change winds during test.<br>ISHFT = 0 Do not change winds.<br>ISHFT = 1 Change winds. |
| Field 4 | NSHFT | Number of hours into simulation to wind shift. |
| Field 5 | IWNDN | Wind speed after shift. |
| Field 6 | IDEGN | Wind direction after shift. |
| Field 7 | ISPEC | Boundary type option<br>ISPEC = 0 Normal solid boundaries.<br>ISPEC = 1 Top and bottom boundaries are reflective.<br>ISPEC = 2 Left and right boundaries are reflective. |

WAVAD "WINDS.DAT" INPUT SPECIFICATIONS Fortran unit 21.

Matrices of wind speeds and directions in 21f6.1 blocked column format. Wind speeds are in knots, and wind directions are mathematical (direction TO WHICH wind is blowing CCW from east). The following subroutines can be used to read and write WINDS.DAT files. These subroutines can be found in the file "WINDIO.FOR" among the software provided with the Florida PCWFS.. The following ng is a sample wind field from a WINDS.DAT file. Note tht the format of the WINDS.DAT is 21f6.1. The records in WINDS.DAT do not wrap around as they do in this document. We have to live with the fonts provided by the word processsor and the laser printer.

```
 96010100
  5.9  5.9  6.2  6.6  6.8  5.7  7.4  6.9  6.5  6.6  7.9  9.9 11.1  7.8  9.0 11.8 13.9 14.5 15.0
15.3 14.3
  5.9  5.9  6.2  6.6  6.8  5.7  7.4  6.9  6.5  6.6  7.9  9.9 11.1  7.8  9.0 11.8 13.9 14.5 15.0
15.3 14.3
  6.6  6.6  6.9  7.3  7.4  5.9  9.3  9.0  8.8  8.9 10.4 12.4  8.4  9.0 10.3 12.8 14.6 15.2 15.6
16.0 14.6
  7.3  7.3  7.6  7.9  8.0  6.3 11.1 11.1 11.2 10.7  7.8  9.4  9.9 10.8 12.0 14.0 15.4 15.9
16.3 16.7 14.9
  8.0  8.0  8.3  8.6  8.5  6.4  7.7  7.8 12.5  7.8  9.2 11.3 11.9 12.7 13.6 15.0 15.9 16.3
16.8 17.0 14.7
  8.2  8.2  8.3  8.4  7.9  4.7  8.4  8.6  8.8  8.7 10.8 12.9 13.1 13.1 13.2 13.3 13.3 13.3
13.3 13.1  7.9
  8.1  8.1  8.1  8.1  7.5  2.9  7.7  8.1  8.2  8.3 10.8 13.2 13.4 13.5 13.5 13.5 13.5 13.8
14.1 14.2 11.2
  8.2  8.2  8.2  8.2  7.6  2.5 12.2 12.9 12.9  8.0 10.2 12.8 13.1 13.2 13.3 13.1 13.0 13.3
13.7 13.9 11.9
  8.2  8.2  8.2  8.2  7.8  1.6 11.1 11.8 12.2 12.1  9.9 12.5 12.7 12.9 13.0 12.5 12.3 12.6
13.0 13.4 12.2
  8.3  8.3  8.3  8.3  7.9  1.0  9.6 10.3 10.7 11.0  9.2 12.1 12.4 12.5 12.6 12.0 11.6 12.0
12.4 12.8 12.4
 10.4 10.4 10.4 10.4 10.1  6.5  9.5  9.4  8.9  8.5  7.7 11.0 11.3 11.5 11.7 11.1 10.4 10.6
10.9 11.3 11.6
  8.6  8.6  8.6  8.6  8.5  7.2  7.7 12.6 11.8 10.4  7.5  9.5  9.4  9.4  9.7  9.7  9.5  9.6  9.8
10.0 10.1
  8.8  8.8  8.8  8.8  8.7  7.4  7.4 12.4 11.4 10.3 11.5  8.2  7.8  7.8  8.2  8.7  9.1  9.3  9.5
9.7  9.6
  8.9  8.9  8.9  8.9  8.9  7.7  7.2 12.1 11.0  9.7 10.5 11.7 11.2 11.2 11.6  8.2  8.8  9.0
9.2  9.4  9.1
  8.8  8.8  8.8  8.8  8.8  7.6  6.9 11.4 10.3  8.8  8.6  8.9  8.1  8.3  9.6 12.4  8.8  8.8  9.1
9.3  8.9
  8.9  8.9  8.9  8.9  8.6  4.6  1.0  1.0  1.2  2.4  4.2  6.8  8.1  9.5 10.6  8.0  9.6 10.2 10.7
11.1 11.0
  7.7  7.7  7.7  7.7  7.8 11.9 12.1  6.8  7.0  7.5  8.0  8.4  8.5  8.6  8.7  9.3 11.0 11.8 12.6
13.3 13.6
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 7.9  7.9  7.9  7.9  7.8  7.3 12.5  7.4  7.6  8.0  8.5  8.8  8.8  8.8  8.8  9.4 10.9 11.7 12.5
13.3 13.7
 8.0  8.0  8.0  8.0  8.0  7.1  7.2  7.4  7.8  8.3  8.7  9.0  9.1  9.1  9.1  9.5 10.7 11.6 12.5
13.3 13.8
 8.2  8.2  8.2  8.2  8.2  7.4  7.2  7.7  8.1  8.6  8.8  9.2  9.2  9.2  9.2  9.4 10.5 11.4 12.3
13.2 13.8
 7.0  7.0  7.3  7.7  8.1  7.7  7.1  7.4  7.4  7.4  6.9  7.3  7.4  7.4  7.4  7.4  7.9  8.3  8.8
9.3  9.5
 6.9  6.9  7.4  8.0  8.7  8.1  7.1 12.6 12.2 11.2  9.6 10.8 10.9 10.9 10.9 10.9 10.9 10.9
10.9 10.9 10.1
 8.1  8.1  8.6  9.2  9.8  8.5  7.1 12.8 12.6 11.6 10.3 11.4 11.5 11.5 11.5 11.5 11.5 11.5
11.5 11.5 10.8
 9.5  9.5  9.9 10.5 11.0  9.0  7.0  7.0 12.5 11.8 10.8 11.9 12.0 12.0 12.0 12.0 12.0 12.0
12.0 12.0 11.5
 10.9 10.9 11.3 11.9 12.3  9.5  7.1  6.8 12.9 12.2 11.3 12.4 12.5 12.5 12.5 12.5 12.5 12.5
12.5 12.5 12.2
 10.9 10.9 11.3 11.9 12.3  9.5  7.1  6.8 12.9 12.2 11.3 12.4 12.5 12.5 12.5 12.5 12.5 12.5
12.5 12.5 12.2
 13.0 12.6 12.3 12.0 11.2  9.7  8.6 12.8 10.9  8.7  7.8  6.7  5.6  4.8  8.3  7.9  7.9  7.9
8.2 13.8 19.4
 13.0 12.6 12.3 12.0 11.2  9.7  8.6 12.8 10.9  8.7  7.8  6.7  5.6  4.8  8.3  7.9  7.9  7.9
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 13.0 12.7 12.4 12.0 11.2  9.9  8.8 12.8 11.3  8.8  7.6  6.4  5.3  4.2  7.4 12.2 12.4 12.4
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 13.1 12.7 12.4 12.1 11.3 10.4  9.2  8.4 11.8  9.5  7.8  6.6  5.4  4.2  6.0 11.0 11.2 11.2
11.2 11.0 15.5
 12.9 12.6 12.3 11.9 11.3 10.9  9.8  8.7  8.0 10.2  8.1  6.9  5.8  4.6  4.7  9.5  9.6  9.6
9.7  9.4 13.4
 6.2  6.8  7.3  7.6  7.7  7.3  7.2  7.2  7.3  9.7  6.7  5.9  5.2  4.4  2.5  7.7  8.2  8.6  9.1
8.4 11.9
 7.8 12.1 11.0  9.6  5.8  9.7  9.6  9.3  9.3  8.0  5.6  5.3  5.1  4.7  1.0  5.7  6.8  7.9  9.2
8.1 10.9
 9.0  8.3  7.6 11.3  6.5  8.3  7.8  7.4  7.4  7.2  6.3  6.0  5.9  5.5  1.2  3.6  5.1  6.7  8.5
11.7  9.7
 9.9  9.0  8.2  7.8  7.1  6.5  5.6  5.0  5.2  6.6  7.1  6.9  6.7  6.4  2.9  2.1  4.0  6.0  8.0
10.6  8.3
 11.0 10.1  9.4  8.8  8.4  5.5  4.0  2.8  2.7  5.6  7.6  7.6  7.5  7.3  4.6  3.1  4.8  6.3  8.1
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 11.4 11.3 11.2 10.9  8.1 11.0 10.9 10.5 10.1 10.7 12.6  7.6  7.5  7.9 12.7 12.6 12.5  7.5
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 9.7 10.3 10.9 11.3  9.9 10.4 11.3 12.1 12.9 13.9 14.3 14.3 14.3 14.3 13.7 12.7 11.9
11.1 10.3  9.7 11.1
 9.2  9.8 10.4 11.0  9.9 10.9 11.7 12.5 13.3 14.3 14.6 14.6 14.6 14.6 14.0 13.0 12.2 11.4
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10.6 10.0 11.7
 8.8  9.5 10.2 10.8 10.2 11.5 12.4 13.1 13.9 14.8 14.9 14.9 14.9 14.8 14.1 13.3 12.6
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13.2 13.4 13.7 15.3
 14.0 14.8 15.7 16.4 16.8 17.0 16.6 16.3 15.9 15.4 14.6 13.8 13.0 12.1 10.8 11.9 13.2
14.4 15.7 17.0 17.2
 14.3 15.1 16.0 16.8 17.4 17.4 17.1 16.6 16.2 15.7 14.7 13.8 13.0 12.1 11.0 12.2 13.5
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7.9  5.3
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16.1 16.1
 20.0 20.4 20.9 22.2 23.7 24.5 25.5 26.1 21.4 18.8 18.8 18.8 18.8 19.0 18.6 17.8 16.9
16.1 16.1
 18.1 18.6 19.2 20.4 21.7 22.7 23.8 24.6 21.0 19.1 19.1 19.1 19.1 19.2 18.6 17.7 16.8
15.9 15.9
 16.1 16.6 17.3 18.5 19.8 21.0 22.2 23.2 20.8 19.4 19.4 19.4 19.4 19.4 18.6 17.7 16.8
15.9 15.9
 14.1 14.8 15.6 16.7 18.1 19.4 20.7 22.0 20.7 19.7 19.7 19.7 19.7 19.7 18.8 17.9 17.0
16.1 16.1
 12.9 13.9 14.9 16.1 17.5 18.9 20.3 21.7 21.4 20.7 20.5 20.3 20.2 20.0 19.4 18.8 18.1
17.5 17.5
 12.2 13.5 14.8 16.2 17.7 19.1 20.6 21.9 22.3 21.6 21.3 21.0 20.7 20.4 20.0 19.7 19.4
19.0 19.0
 10.9 12.4 13.9 15.5 17.0 18.6 20.1 21.6 22.5 22.0 21.7 21.4 21.1 20.7 20.4 20.1 19.8
19.5 19.5
 9.8 11.5 13.2 14.9 16.6 18.3 19.9 21.5 22.8 22.5 22.1 21.8 21.5 21.1 20.8 20.5 20.2
19.8 19.8
 9.2 11.1 12.9 14.7 16.4 18.1 19.8 21.5 23.0 22.8 22.4 22.1 21.8 21.5 21.2 20.8 20.5
20.2 20.2
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 10.2 11.8 13.3 14.8 15.9 17.0 18.1 19.1 20.2 20.3 20.3 20.3 20.3 20.3 20.1 20.0 19.8
19.6 19.6
 11.7 12.9 14.0 15.1 15.6 16.0 16.4 16.8 17.2 17.6 18.0 18.3 18.7 19.0 19.0 19.0 19.0
19.0 19.0
 12.3 13.4 14.6 15.5 15.9 16.3 16.6 17.0 17.4 17.8 18.2 18.5 18.9 19.3 19.3 19.4 19.4
19.4 19.4
 12.9 14.1 15.2 16.0 16.3 16.7 17.0 17.4 17.8 18.2 18.5 18.9 19.3 19.7 19.8 19.8 19.8
19.8 19.8
 13.8 14.9 15.9 16.5 16.6 16.9 17.3 17.7 18.0 18.4 18.7 19.1 19.5 19.9 20.0 20.0 20.0
20.0 20.0
 15.6 15.8 15.9 15.2 14.7 14.7 14.7 14.7 14.6 14.9 15.3 15.7 16.2 16.6 16.7 16.7 16.7
16.7 16.7
 16.5 15.8 15.0 13.5 12.6 12.1 11.7 11.3 10.8 11.2 11.6 12.1 12.5 12.9 13.2 13.2 13.2
13.2 13.2
 16.6 15.8 15.0 13.6 12.7 12.3 11.8 11.3 10.9 11.3 11.8 12.2 12.7 13.1 13.3 13.3 13.3
13.3 13.3
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 54.2 54.2 50.2 46.4 41.3 351.5 302.9 289.5 275.1 260.1 248.3 234.8 225.0 237.7 233.6 239.4
245.4 244.0 242.3 240.3 230.3
 54.2 54.2 50.2 46.4 41.3 351.5 302.9 289.5 275.1 260.1 248.3 234.8 225.0 237.7 233.6 239.4
245.4 244.0 242.3 240.3 230.3
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315.8 318.3 320.6 323.3 337.6
 90.0 90.0 90.0 90.0 90.0 271.5 276.6 281.9 287.8 311.3 312.6 309.7 311.0 312.4 313.8 316.0
319.5 322.2 324.7 327.4 339.0
 90.0 90.0 90.0 90.0 90.0 272.4 276.8 282.9 288.9 295.8 313.0 310.7 312.0 313.4 314.9 317.7
321.9 324.7 327.3 330.0 338.6
 92.4 92.4 92.4 92.4 92.5 251.6 276.0 283.2 290.3 297.2 314.1 311.0 312.4 314.1 315.8 319.3
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324.4 327.3 329.9 332.5 338.0
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322.7 325.3 327.7 329.9 332.1
 170.1 170.1 170.1 170.1 171.3 199.6 229.2 212.7 215.5 221.2 261.6 280.8 289.7 298.5 307.1 315.8
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 173.2 173.2 173.2 173.2 174.1 194.1 216.0 197.2 198.6 202.5 225.3 248.9 263.3 278.3 292.7 319.5
322.6 324.6 326.5 328.5 333.1
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337.7 339.6 341.7 343.9 350.6
  63.9  63.9  63.9  63.9  60.8  24.8   6.0  26.4  28.1  26.9  16.4   6.7   6.2   6.1   5.4 356.3 349.2
350.9 352.8 354.7    .6
  61.4  61.4  61.4  61.4  60.9  44.1  10.3  30.1  31.7  30.5  19.2   8.7   8.1   8.1   7.7 359.5 354.1
355.6 357.3 359.0   4.9
  61.1  61.1  61.1  61.1  60.7  50.6  35.0  35.8  35.0  33.6  20.8   8.8   8.2   8.2   7.9   2.4 359.0    .3
  1.7   3.2   9.0
  61.3  61.3  61.2  61.1  60.6  52.0  40.9  39.3  38.4  36.7  22.4   8.9   8.2   8.2   8.0   5.3   3.9   5.0
  6.1   7.4  13.1
  70.2  70.2  67.7  65.2  62.6  53.6  45.2  42.5  42.7  41.9  23.0   3.4   2.5   2.5   2.5   2.4   3.2   4.2
  5.0   6.2  14.1
  86.0  86.0  80.0  74.3  69.0  55.1  41.0  19.8  20.5  21.0 357.6 333.5 332.3 332.3 332.3 332.3 332.4
332.5 332.6 333.2 343.1
  89.6  89.6  83.8  78.3  72.9  56.3  37.1  15.5  15.2  15.4 353.8 332.5 331.5 331.5 331.5 331.5 331.5
331.5 331.5 331.8 339.1
  91.8  91.8  86.4  81.3  76.1  57.5  35.5  30.5  10.8  10.1 350.8 332.5 331.7 331.7 331.7 331.7 331.7
331.7 331.7 331.9 336.5
  93.5  93.5  88.5  83.7  78.7  58.6  31.7  28.0   6.0   5.0 348.1 332.5 331.8 331.8 331.8 331.8 331.8
331.8 331.8 331.9 334.3
  93.5  93.5  88.5  83.7  78.7  58.6  31.7  28.0   6.0   5.0 348.1 332.5 331.8 331.8 331.8 331.8 331.8
331.8 331.8 331.9 334.3
 220.4 220.3 220.8 221.0 213.5 205.5 204.1 183.5 183.6 189.7 196.9 200.1 204.1 213.0 251.4 283.3
289.6 294.2 298.4 298.7 300.7
 220.4 220.3 220.8 221.0 213.5 205.5 204.1 183.5 183.6 189.7 196.9 200.1 204.1 213.0 251.4 283.3
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267.0 273.0 279.8 300.4 304.0
 215.0 214.2 214.5 213.9 195.8 177.7 173.9 170.3 163.4 149.1 161.6 159.8 155.7 153.1 230.8 259.5
267.1 274.3 282.2 302.9 306.8
 222.4 219.6 216.4 211.0 156.0 144.1 142.7 141.8 139.8 129.0 141.3 137.2 130.3 123.7 233.2 270.0
280.9 291.1 300.4 316.4 317.5
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302.9 314.4 322.7 331.9 330.7
 350.1 345.8 339.4 315.9 352.7  57.0  70.7  85.0 100.0 115.3 114.1 108.6 102.7  96.7  86.9 302.4
319.8 330.6 335.7 323.6 338.8
 344.0 340.7 336.1 329.4 335.8  44.5  61.9  82.4 104.8 118.7 111.9 106.7 101.3  95.8  88.7 342.1
348.2 352.1 352.7 336.7 350.9
 338.8 335.2 330.8 325.8 323.1  22.3  38.6  64.4 105.8 117.0 105.3 103.3  98.5  93.6  81.6  35.5
20.4  15.7  11.1 354.6   6.4
 331.7 331.0 330.3 330.4 347.8   1.5   2.0   2.1   3.5  24.4  40.0  59.8  60.8  57.2  29.4  19.9  19.5
38.1  38.9  30.2  23.7
 331.3 334.2 336.7 339.9   1.8  25.7  26.5  26.2  26.3  33.7  40.8  41.8  41.8  41.5  34.6  28.5  28.5
30.2  30.9  31.7  30.5
 335.0 338.1 340.8 344.1   7.3  31.9  32.3  31.5  31.1  35.8  40.9  41.1  41.1  40.7  33.0  25.1  24.9
25.3  26.0  32.7  37.0
 339.3 342.4 345.0 348.3  12.6  36.6  36.6  35.5  34.8  37.5  40.8  40.9  40.9  40.5  31.1  21.1  20.6
20.6  21.3  33.9  43.1
 344.7 347.7 350.1 353.3  18.1  40.7  40.5  39.3  38.3  39.1  40.7  40.8  40.8  40.3  29.2  17.1  16.3
16.0  16.6  34.8  48.3
 357.6 359.4    .7   2.8  22.4  40.5  41.2  40.9  40.6  40.4  41.0  41.5  42.2  42.1  28.4  13.3  12.6
12.8  13.9  32.6  48.8
   6.2   7.2   7.9   9.3  23.0  36.4  37.4  37.8  38.2  37.9  38.0  39.0  40.2  41.0  30.9  18.9  18.5  18.6
19.4  31.2  43.1
  10.3  11.2  11.7  12.7  23.8  34.7  35.6  36.0  36.4  35.2  34.2  35.0  36.0  36.8  32.2  25.6  24.8
24.4  24.5  31.9  39.9
  14.4  15.0  15.3  16.0  24.6  33.2  33.9  34.3  34.5  32.4  30.4  30.9  31.6  32.4  33.3  32.0  30.9
30.0  29.5  32.6  36.9
  18.4  18.7  18.8  19.2  25.5  31.9  32.5  32.8  33.0  29.9  26.7  26.9  27.4  28.2  34.6  38.4  37.0
35.6  34.5  33.6  34.1
  21.8  22.2  22.3  22.7  29.9  37.1  37.8  38.2  38.3  31.7  24.2  23.8  23.8  24.6  40.4  52.5  51.9
50.7  49.4  43.2  38.6
 353.6 353.7 352.9 353.3  23.8  46.0  46.9  46.9  46.4  33.1  12.8  10.3   9.0   9.5  29.4  47.0  50.8
54.3  57.7  53.9  47.3
 345.9 344.8 342.7 341.7  17.9  46.3  47.4  47.4  46.9  37.0  20.6  17.3  15.2  14.6  28.7  43.4  47.4
51.1  54.9  50.1  40.3
 339.9 338.0 335.2 333.2  12.0  46.0  47.2  47.2  46.9  40.5  28.8  24.8  22.0  20.4  28.6  39.6  43.3
47.1  51.0  44.1  29.8
 334.7 332.1 328.8 326.4   6.3  45.6  47.0  47.0  46.8  43.5  35.4  31.2  27.9  25.5  28.4  35.5  39.0
42.8  46.6  37.2  17.4
 334.7 332.1 328.8 326.4   6.3  45.6  47.0  47.0  46.8  43.5  35.4  31.2  27.9  25.5  28.4  35.5  39.0
42.8  46.6  37.2  17.4
 304.9 309.2 313.2 316.1 319.2 323.0 326.5 330.4 351.8  19.8  21.5  21.5  21.8  29.3  37.2  38.5
39.5  40.6  40.6
 304.9 309.2 313.2 316.1 319.2 323.0 326.5 330.4 351.8  19.8  21.5  21.5  21.8  29.3  37.2  38.5
39.5  40.6  40.6
 306.9 311.6 316.0 319.3 322.8 326.8 330.4 334.5 355.1  20.1  21.5  21.5  21.8  27.3  33.4  34.4
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35.2  36.1  36.1
 309.4 314.7 319.5 323.3 327.3 331.5 335.2 339.3 358.7  20.3  21.5  21.5  21.7  25.3  29.4  30.1
30.7  31.3  31.3
 313.0 318.9 324.2 328.6 333.0 337.3 340.9 344.8   2.5  20.5  21.5  21.5  21.6  23.4  25.4  25.8  26.1
26.5  26.5
 323.8 329.6 334.5 338.8 342.8 346.1 349.0 352.2   6.6  20.6  21.4  21.4  21.4  21.5  21.7  21.7  21.8
21.8  21.8
 336.3 341.3 345.5 348.9 351.8 354.2 356.3 358.6   9.6  19.7  20.3  20.3  20.3  20.3  20.3  20.3  20.3
20.3  20.3
 345.5 350.0 353.6 356.5 358.8    .8   2.4   4.2  11.9  18.8  19.1  19.1  19.1  19.1  19.1  19.0  19.0
19.0  19.0
 356.5    .0   2.6   4.7   6.3   7.7   8.8   9.9  14.2  17.9  18.0  18.0  18.0  17.9  17.9  17.8  17.8  17.8
17.8
   9.6  11.2  12.4  13.4  14.1  14.7  15.2  15.6  16.5  17.0  16.9  16.9  16.8  16.8  16.7  16.7  16.6
16.5  16.5
  22.9  22.5  22.2  21.9  21.7  21.6  21.5  21.3  18.4  15.6  15.4  15.4  15.4  15.4  15.3  15.3  15.2
15.2  15.2
  29.5  28.6  27.8  25.6  23.9  23.7  23.6  23.3  19.6  16.1  16.0  16.1  16.2  15.6  14.9  14.9  14.9
14.9  14.9
  35.7  34.3  33.0  29.0  25.6  25.3  25.2  24.9  21.2  17.6  17.5  17.6  17.6  16.3  15.0  15.0  15.0
15.0  15.0
  41.5  39.7  38.0  32.2  27.3  26.9  26.7  26.4  22.7  19.2  19.0  19.0  19.0  17.1  15.2  15.1  15.1
15.1  15.1
  46.7  44.7  42.7  35.4  29.0  28.5  28.3  27.9  24.2  20.7  20.5  20.5  20.3  17.8  15.2  15.1  15.1
15.1  15.1
  49.2  48.9  48.1  40.3  32.0  31.6  31.6  31.4  27.0  22.6  22.3  22.3  22.0  18.0  14.1  13.9  13.9
13.9  13.9
  44.7  45.9  46.9  40.4  32.2  32.1  32.5  32.7  29.6  25.8  25.4  25.2  24.7  18.5  12.4  12.1  12.1
12.1  12.1
  41.3  42.5  43.4  37.5  30.0  29.9  30.2  30.5  29.7  28.2  27.9  27.6  26.9  19.5  12.4  12.0  12.0
12.0  12.0
  38.0  38.9  39.7  34.3  27.7  27.5  27.8  28.1  29.6  30.5  30.1  29.8  29.0  20.6  12.6  12.1  12.1
12.1  12.1
  34.9  35.7  36.3  31.4  25.5  25.3  25.5  25.9  29.7  32.9  32.6  32.2  31.3  21.7  12.5  12.0  12.1
12.1  12.1
  39.7  41.3  42.8  35.9  25.9  25.2  25.0  25.4  34.7  43.7  44.3  44.5  43.8  24.9   5.8   5.7   6.3   6.8
6.8
  53.8  63.0  73.8  82.2  46.4  29.3  21.4  17.8  29.6  46.5  54.5  63.6  73.8  56.4 309.5 324.9 334.3
339.7 339.7
  47.3  58.4  72.8  87.9  65.5  47.4  35.9  28.8  29.0  38.9  47.3  58.4  72.3  82.1 334.1 344.9 349.8
352.2 352.2
  35.7  47.1  65.3  87.8  72.7  58.3  47.2  38.8  28.8  28.6  35.7  47.1  64.8  84.6  29.1  15.2  10.3
7.8   7.8
  20.5  29.3  50.2  87.8  76.4  64.7  54.7  46.1  28.7  16.7  20.5  29.3  49.6  85.9  56.8  37.9  27.4
21.5  21.5
```

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 20.5  29.3  50.2  87.8  76.4  64.7  54.7  46.1  28.7  16.7  20.5  29.3  49.6  85.9  56.8  37.9  27.4
21.5  21.5
```

## WAVAD “WRMSTR.BN” INPUT DATA SPECIFICATIONS Fortran unit 23.

This file contains data necessary for a warm start of the current run. The necessity of this file is determined by the NSTR option set in file OPTIONS.DAT. If a cold start is selected ( NSTR = 0 or 1), this file is never read. This file must be written by a previous model run with the write data for next run option selected (NSTR = 1 or 3). This file can also be written by the forecast model using the NHRSAV option. This file is unformatted.

## WAVAD “BNDIN.BN” INPUT SPECIFICATIONS Fortran unit 25.

This file contains all boundary data coming WAVAD. This information can be from an independent source or from a previous run of WAVAD with IBND = 1 or 3. If the boundary information is form an independent source, care must be taken to include equivalent information to that written by WAVAD with IBND = 1 or 3.

## OUTPUT FILES.

ONELNS.DAT One-line summaries for special output points. The summary data is as follows:

| | | | |
|---|---|---|---|
| Field 1 | IDN | date-time code YYMMDDHH | - (i8) |
| Field 2 | I | I-location of point | - (i5) |
| Field 3 | J | J-location of point | - (i5) |
| Filed 4 | HSIG | Significant height | -(f7.1) |
| Field 5 | HTSWL | Swell height (m) | -(f7.1) |
| Field 6 | TOA | Aerage wave period (s) | -(f7.1) |
| Field 7 | TTT | Swell period (s) | -(f7.1) |
| Field 8 | SWANGT | Significant wave angle (d) | -(f7.0) |
| Field 9 | ANGSWL | Swell angle (d) | -(f7.0) |
| Field 10 | WS | Wind speed (k) | -(i7) |
| Field 11 | WD | Wind direction (d) | -(i7) |

The following is a sample from a ONELNS.DAT output file

```
96010112    8  26      .0       .0       .7      .0    190.     0.     1    190
96010112   10  26      .0       .0       .7      .0    190.     0.     1    190
96010112   12  26      .0       .0       .7      .0    205.     0.     1    205
96010112   14  26      .0       .0       .7      .0    215.     0.     1    215
96010112   16  25      .0       .0      1.1      .0    250.     0.     3    250
96010112   17  23      .1       .0      1.5      .0    265.     0.     4    265
96010112   19  24      .2       .0      2.2      .0    275.     0.     6    275
```

ONED.DAT One-dimensional spectra for special output points. The first record in each set contains IDN, I,J in Format (i10,2i4). The next record contains energy densities in M**2/Hz for each of the modelled frequencies in Format (10f8.2).

The follwong is a sample from a ONED.DAT output file

```
96010112  8 26
  .00   .00   .00   .00   .00   .00   .00   .00   .00   .00
  .00   .00   .00   .00   .00
96010112 10 26
  .00   .00   .00   .00   .00   .00   .00   .00   .00   .00
  .00   .00   .00   .00   .00
96010112 12 26
  .00   .00   .00   .00   .00   .00   .00   .00   .00   .00
  .00   .00   .00   .00   .00
96010112 14 26
  .00   .00   .00   .00   .00   .00   .00   .00   .00   .00
  .00   .00   .00   .00   .00
96010112 16 25
  .00   .00   .00   .00   .00   .00   .00   .00   .00   .00
  .00   .00   .00   .00   .00
96010112 17 23
  .00   .00   .00   .00   .00   .00   .00   .00   .00   .00
  .00   .00   .00   .00   .00
```

TWOD.DAT Two-dimensioanl spectra for special output points. Data are written in blocks. The fiorst record in each block contains the follwing fields

| | | | |
|---|---|---|---|
| Field 1 | IDN | date-time code YYMMDDHH | - (i8) |
| Field 2 | I | I-location of point | - (i5) |
| Field 3 | J | J-location of point | - (i5) |
| Filed 4 | WINSP | Wind speed | -(f7.1) |
| Field 5 | INDR | Wind direction | -(f7.1) |
| Field 6 | FRSTDY | Peak frequency (hz) | -(f10.4) |
| Field 7 | FSEA | Frequency of local sea(hz) | -(f10.4) |
| Field 8 | FRSWL | Frequency of swell | -(f10.4) |

The initial record is followed by NFRQ records each containing NANG field of energy density in M**2/HZ for the given frequency and direction bands. Frequencies and angles are written in order increasing from smallest to largest. The Format is (12i6).

The follwing is a sample from a TWOD.DAT output file

```
96010112   8  26   1.0  190.0   1.3991    1.3991 1000.0000
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
96010112  10  26   1.0  190.0   1.3991    1.3991 1000.0000
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0
    0    0    0    0
```

| | |
|---|---|
| WAVES.DAT | This file contains wave height, period, and direction fields for the entire model grid. The filed are written in blocks.. The first record in each block contains the date-time code (IDN) and the time counter (IHR) in Format(2i10). This record is followed by three geographically oriented matices. The first matrix contains the wave height in tenths of meters, the second contains the wave periods in tenths of seconds, and the third contains the wave direction in degrees. All are written in Format(26i5). This file can be very large. |

The following is a sample wave field from a WAVES.DAT file.

```
  96010112         1
    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5
    5
    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5
    5
    5    5    5    5    5    5    5    5    5
    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5
    5
    5    5    5    5    5   11   10   10    5    5    9    9    8    8   10   14   14   13   14   24   34   35   36
   36   30   26
   26   26   26   20   18   16   15   14    5
    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5
    5
    5    5    5    5   12   11   11   10   10   10   10    9    8    8    9   13   11   11   12   22   30   31
   32   33   28   25
   25   25   26   20   17   16   15   14    5
    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5
    5
    5    5    5    5    5   11   11   11   10    9   10    9    9   11    8   11   10   10   10   19   26   27   28
   28   27   24
   24   25   25   20   18   16   15   14    5
    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5
    5
    5    5    5   11   12   11   11   11   10   10    9    9    9    8    7    9    9    9    9   16   22   23   24
   26   24   23
   23   24   24   21   18   16   15   14    5
    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5
    5
    5    7    8   10    8    8    8    8    8    8    8    8   11   10    8    8   12   12   12   13   20   21   22
   23   24   24
   24   24   25   23   20   20   18   18    5
    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5    5
```

```
5
 9 7 6 5 5 6 8 8 10 7 10 10 10 9 7 8 8 9 10 11 18 20 21
22 23 23
 24 24 26 23 23 23 22 22 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
10
 11 9 8 7 5 6 7 9 9 6 7 10 10 10 7 6 5 6 8 9 16 17 19 21
23 22
 23 24 24 24 23 23 23 23 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
11
 8 7 10 10 7 6 7 8 9 7 7 7 10 11 8 5 5 5 6 8 14 15 17 19
21 23
 23 24 26 24 24 24 23 23 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
12
 9 8 8 8 8 6 7 8 9 6 7 7 7 11 9 6 5 6 8 11 12 14 15 18
20 21
 22 24 26 26 24 24 24 24 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 15
13
 13 13 13 12 9 11 9 8 8 7 7 8 8 7 11 11 8 8 9 8 12 14 15
16 18 19
 21 22 23 23 23 23 23 23 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 14 15
15
 15 15 16 16 15 14 14 14 14 14 15 14 14 14 13 13 12 13 12 11 14
15 16 17 17 18
 20 20 21 21 21 22 22 22 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 12 13 13
14 15
 15 15 16 17 17 16 16 16 16 16 15 15 15 14 13 13 12 13 12 12 14
15 16 17 17 18
 20 20 21 21 22 22 22 23 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 9 11 12 13
14 14
 15 15 16 16 17 16 16 16 16 16 15 15 15 14 14 13 13 13 13 12 14
15 16 17 17 18
 20 21 21 23 23 23 23 23 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 8 9 10 11 12
13 14
 14 15 16 17 17 16 16 16 16 16 16 15 15 14 14 13 14 13 14 12 14
15 16 17 18 18
 20 21 23 23 23 23 23 24 5
 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 11 7 9 9 10
```

```
11  12
 13  13  14  15  15  15  16  16  16  16  16  15  15  14  14  14  15  15  15  14  14
15  16  16  17  17
 18  19  19  21  21  21  21  21   5
 5  5  5  5  5  5  9  8  7  8  8  5  5  5  5  5  8  5  5  9  11  13  8  8  8
9
 10  11  12  14  13  14  14  14  15  16  16  15  14  15  14  15  15  15  15  14  14
15  15  16  16  17
 17  17  18  18  18  17  17  17  5
 5  5  5  5  10  9  8  7  8  11  7  5  5  5  5  5  8  8  5  5  10  12  12  7
8  8
 9  10  11  14  14  14  14  15  16  16  16  16  15  15  15  15  15  16  15  14  15  15
16  16  17  17
 17  18  18  19  18  18  17  17  5
 5  5  5  10  10  9  7  11  11  10  6  5  5  5  5  5  7  7  5  5  9  11  5  12
7  7
 8  10  11  12  15  14  14  15  16  17  16  16  15  16  15  16  16  16  16  16  15  16
16  17  17  17
 18  18  19  19  20  19  19  18  5
 5  5  5  10  10  8  11  10  9  8  5  5  5  5  5  5  6  6  7  5  8  10  11  12
7  7
 8  10  11  12  15  15  16  15  16  17  16  16  17  16  15  16  16  17  16  16  15  16
16  17  17  18
 18  19  19  19  20  19  19  19  5
 5  5  5  9  9  8  10  9  7  7  5  5  5  5  5  5  6  7  7  5  9  9  5  10  5
11
 11  7  8  9  9  9  9  10  10  10  10  11  11  11  11  11  10  10  10  9  9  10
10  11  11  11
 12  12  12  12  12  12  12  12  5
 5  5  5  8  9  7  9  9  8  7  6  6  6  6  6  6  7  8  9  10  10  10  10  10
9  5
 9  9  9  9  9  9  8  8  7  6  7  9  11  11  8  6  6  10  9  7  6  8  9  10
7  6
 6  6  6  6  6  10  10  10  5
 5  5  5  9  9  7  8  9  8  7  6  6  6  6  6  6  7  5  5  5  5  11  11  10
10  9
 5  9  9  9  9  9  8  8  7  7  8  10  11  7  8  6  10  9  8  7  7  8  10  6
6  6
 6  6  6  6  6  11  10  10  5
 5  5  5  10  10  7  8  8  8  7  6  6  6  6  6  6  5  5  5  5  5  5  5  11
10  9
 10  10  10  10  10  9  8  8  7  7  10  11  12  7  7  6  10  9  8  7  8  9  11
6  7  6
 6  6  6  6  6  6  10  11  5
 5  5  5  10  10  7  9  8  8  7  5  5  5  5  6  6  5  5  5  5  5  5  5  5  5
```

```
 9
  10 10 10 10 10 9 9 8 7 8 12 7 7 8 7 6 10 8 7 7 10 6 6 7
 7 7
  7 7 7 7 6 6 7 12 5
  5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
 5
  5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
 5
  5 5 5 5 5 5 5 5 5
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15
  15 15 15 15 15 15 15 15 15
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15
  15 15 15 15 15 44 41 40 15 15 37 37 34 32 41 52 52 49 52 71 80
 81 82 82 76 71
  71 71 71 61 59 57 54 51 15
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15
  15 15 15 15 45 44 42 39 39 39 41 38 34 34 38 49 45 45 45 65 76
 77 78 79 71 71
  71 71 71 63 58 57 54 51 15
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15
  15 15 15 15 15 44 43 42 39 38 40 38 38 44 34 45 41 41 41 61 71
 71 76 76 71 67
  67 71 71 63 59 57 54 51 15
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15
  15 15 15 44 46 44 43 42 39 39 39 37 37 34 30 38 38 38 38 56 66
 67 71 71 71 67
  67 67 67 64 59 57 54 51 15
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15
  15 28 33 39 34 33 33 35 34 33 34 32 43 40 34 34 47 47 48 49 62
 64 65 67 67 67
  67 67 71 66 63 63 60 60 15
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
 15 15 15 15 15
  39 30 23 19 16 26 33 35 39 27 40 39 40 35 30 34 34 38 41 45 60
 63 64 67 67 67
  67 71 71 67 66 66 65 65 15
  15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
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15 15 15 15 41
 42 37 33 30 19 25 30 36 38 24 29 39 41 40 30 23 19 23 34 38 56
59 62 65 67 67
 67 71 71 67 67 67 67 67 15
 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
15 15 15 15 43
 33 30 39 39 28 23 28 33 38 28 27 29 40 42 34 16 12 16 27 34 52
55 58 63 66 67
 67 71 71 71 67 67 67 67 15
 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
15 15 15 15 46
 38 34 31 31 33 23 30 34 36 26 28 30 30 44 39 23 19 23 34 45 49
52 56 61 64 66
 67 71 71 71 67 67 67 67 15
 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
15 15 15 52 48
 49 49 49 46 38 44 37 34 32 30 30 34 32 30 43 43 34 34 38 34 49
52 55 58 60 62
 64 65 66 66 66 67 67 67 15
 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
15 15 51 53 51
 51 52 55 55 54 53 53 53 53 53 54 52 51 50 47 49 47 49 47 45 51
53 55 58 58 60
 62 62 64 64 64 65 65 65 15
 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
46 48 49 51 51
 51 52 55 57 57 55 55 55 55 55 54 53 52 50 48 49 47 49 48 49 51
53 56 58 58 60
 62 63 64 64 65 65 65 67 15
 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 37
43 46 48 51 50
 52 53 56 56 57 55 55 55 55 55 54 53 52 51 50 49 49 50 50 49 51
54 56 58 59 60
 63 64 64 66 66 66 67 67 15
 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 34 35
40 43 46 49 50
 52 53 56 57 57 55 55 55 55 55 56 54 53 51 51 50 52 50 51 49 52
54 56 59 60 60
 63 64 66 66 67 67 67 67 15
 15 15 15 15 15 15 15 15 15 15 15 12 12 12 12 15 15 15 15 42 30
38 38 41 44 47
 50 50 53 54 54 54 55 55 55 56 56 54 54 52 52 53 53 53 53 53 53
54 55 55 57 57
 59 61 61 64 64 64 64 64 15
 15 15 15 15 15 15 38 33 30 32 32 12 12 12 12 19 34 15 15 38 45
```

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50 34 34 34 38
 41 45 49 51 50 53 53 52 53 54 55 54 53 53 52 54 54 53 54 53 52
53 53 54 54 55
 56 56 59 59 59 57 57 57 15
 15 15 15 15 40 36 34 30 32 44 30 12 12 12 12 19 34 34 15 15 41
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 38 41 45 51 51 53 53 54 55 54 55 55 54 53 55 54 54 55 54 53 54
53 55 54 55 55
 56 58 59 60 59 59 57 57 15
 15 15 15 40 40 36 30 43 42 40 23 12 12 12 12 16 30 30 15 15 38
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56 55 56 55 56
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 34 41 45 49 53 54 55 54 55 56 56 55 57 56 55 57 56 57 55 55 54
56 55 56 55 58
 58 60 60 60 61 60 60 60 15
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39 15 40 15 44
 44 30 34 37 39 37 37 40 40 40 40 42 42 44 42 43 40 40 40 36 36
39 41 43 43 43
 45 45 45 45 46 46 45 45 15
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 36 36 36 36 36 36 33 32 30 27 30 38 44 44 34 26 26 39 36 28 25
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 26 26 26 24 26 39 41 40 15
 15 15 15 35 37 30 33 38 34 30 23 23 23 23 23 23 30 15 15 15 15
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15 15 42 41 38
 40 40 40 40 39 36 34 34 30 30 41 44 46 30 30 26 39 36 31 28 34
36 42 26 30 26
 26 26 26 25 25 26 41 42 15
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15 15 15 15 38
 40 40 40 40 40 37 35 34 30 34 46 30 30 34 30 26 39 33 27 28 39
26 26 30 30 30
 29 28 27 27 26 26 30 45 15
 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15 15
```

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 15  15  15  15  15
  15  15  15  15  15  15  15  15  15  15  15  15  15  15  15  15  15  15  15  15  15
 15  15  15  15  15
  15  15  15  15  15  15  15  15  15
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0   0   0   0   0   0   0   0   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0   0   0   0   0 190 190 190   0   0 225 225 230 235 260 270 275 280 285 288
298 300 305 310 323 332
 339 340 342 352  23  33  39  37   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0   0   0   0 190 190 190 190 190 205 215 220 220 220 250 270 275.280 285 290
297 303 307 313 323 335
 339 340 341 351  10  32  34  35   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0   0   0   0   0 185 185 185 185 200 210 210 210 195 245 265 270 275 285 290
297 303 308 313 326 335
 339 341 345 353  11  25  29  32   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0   0   0 190 185 185 185 180 180 195 205 205 200 200 235 260 265 275 280 290
300 306 312 318 331 339
 340 345 346 357  10  24  30  34   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0 180 180 175 180 170 170 170 170 190 190 195 175 170 215 265 255 270 280
305 310 315 320 323 336 344
 345 350 350   1  14  21  22  22   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
 340 335 310 245 165 135 140 145 150 185 165 165 165 130 200 255 275 295 310
326 319 324 328 334 341 349
 350 352 354   4  18  20  20  21   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
330
 330 320 305 255 210 145 150 155 160 170 180 160 125 125 180 240 275 315 325
325 323 328 332 339 345 352
 354 355 356   6  18  20  20  20   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
```

```
325
 335 330 300 255 230 170 170 170 170 170 180 145 125 120 130 190  60   0   0
335 330 334 340 342 350 355
 355 360   1  10  19  20  20  20   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
325
 330 320 315 310 245 195 185 180 180 175 150 145 140 115 120 110  85  45  30
337 348 350 353 348 354 359
 359 359   2   9  17  19  20  20   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 325
331
 332 332 331 330 340 345 345 340 340  30  56  75  75  75  54  45  55  50  45  15
355 355 359 358 357 360
 360   1   4   9  18  19  19  19   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 330
331 336
 345 346 350 350   6  12  12  12  17  30  43  42  44  49  45  41  41  39  38  22 359
358   3   3   2   1
   1   5   5  14  23  24  24  24   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 325 332 331
335 341
 351 350 350 355   6  17  17  17  17  30  42  43  43  43  41  41  41  39  42  25   8
4   3   8   6   6
   6   7   6  15  24  24  24  23   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 330 330 335 336
340 346
 351 355 356 356  11  18  18  18  18  30  38  43  43  44  40  34  35  34  34  25  10
9   8   8   8  10
  11  10  11  20  22  22  22  23   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 330 335 335 335
340 344 351
 357 357   0   1  10  17  18  18  18  25  38  37  38  38  40  34  34  34  38  24  15
14  14  13  11  10
  10  10  14  19  20  20  20  20   0
   0   0   0   0   0   0   0   0   0   0   0 180 190 195 225   0   0   0   0 310 325 330
335 340 340 349
 358 357   1   2  11  18  17  17  17  24  38  37  38  38  35  37  36  36  34  27  15
17  16  16  15  15
  15  14  14  19  24  25  25  25   0
   0   0   0   0   0   0  80  85  95 100  85  90 165 165 275 275 280   0   0 295 300
300 325 335 340   0
  11  11  10   8  11  18  17  19  22  25  33  33  34  37  37  37  37  36  35  27  14  16
17  17  16  16
  15  15  15  20  28  27  28  28   0
   0   0   0   0  75  70  70  80  85  75  85  85   0   0 280 275 280 290   0   0 300 305
```

```
310 335 345 350
  11  11  11  12  14  21  20  21  21  25  30  34  34  34  35  37  36  35  36  28  16
16  16  16  16  16
  20  20  20  20  24  24  23  23   0
   0   0   0  70  75  70  60  54  60  70  85  85   0   0 280 275 280 290   0   0 305 325
 0 339 345 355
  11  11  20  17  16  25  25  25  25  25  30  30  31  30  35  40  40  40  35  30  21
21  20  20  20  20
  20  20  20  20  24  23  23  23   0
   0   0   0  70  70  65  40  45  55  65  80  55   0   0 315 280 285 295 300   0 310
315 335 347 350   5
  11  11  20  20  24  30  29  30  25  25  25  25  24  25  32  39  39  40  39  30  20
20  20  20  20  20
  20  20  20  20  24  23  23  23   0
   0   0   0  75  75  65  30  35  40  50  45   5   0   0 355 320 310 315 320   0 330
330   0 335   0 355
   5  20  25  25  30  35  35  35  35  30  25  25  25  25  35  49  50  50  50  40  25  25
 25  20  25  25
  25  25   3   3  15  11 355 355   0
   0   0   0  80  80  70  25  30  30  35  25   0 355 355 355 335 325 330 330 335 335
330 330 330 330   0
   5   5   5   5  15  25  30  30  35  35  20  20  15  15  40  55  60  45  50  50  20  15
10  10  25  25
  25  30  30  25  15 350 355 355   0
   0   0   0  85  80  65  20  20  25  30  20   0 355 355 355 340 330   0   0   0   0 330
330 330 330 350
   0   5   5   5  10  20  20  25  30  35  30  25  20  40  45  50  30  35  45  50  35  25
20  40  35  25
  25  30  30  25  10 350 350 350   0
   0   0   0  80  80  65  15  15  15  20  10   0 355 355 355 350   0   0   0   0   0   0
 0 330 330 345
   5   5   5   5  10  15  15  15  20  40  40  35  30  50  45  40  20  25  35  50  45  35
30  50  35  25
  25  25  30  25  15   5 345 345   0
   0   0   0  80  80  65  10  10  10  10   0   0   0   0 355 355   0   0   0   0   0   0   0
 0   0 345
   5   5   5   5  10   5  10  10  10  45  50  65  60  55  45  35  10  15  20  50  50  65
60  55  40  25
  25  25  25  20  15  10   0 345   0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0
   0   0   0   0   0   0   0   0   0
```

| | |
|---|---|
| MAXFILE.DAT | Maximum height field with associated period and direction fields. This file is simlar to WAVES.DAT, but contains only one set of fields. The first matrix gives the maximum wave hright at every point in the grid, the second matrix gives the associates wave periods and gives the associates wave direction. The height and period matrices are written with Format(61f6.1) and the direction matrix is written with Format(61f6.0). |

The following is a samples of MAXFILE.DAT. As with the WINDS.DAT file, the records in MAXFILE.DAT do not wrap around.

```
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  2.6  3.1  4.0  4.6
4.7  5.0  5.3  5.4  5.4  5.5  5.6   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  3.0  3.2  3.3  3.6  5.1
5.5  5.6  5.7  5.7  5.8  5.9  6.0   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  2.5  3.3  3.4  3.5  3.7  4.2
5.5  5.5  5.6  5.6  5.8  5.9  6.2   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  2.8  3.2  3.6  3.6  4.0  3.9  4.3
4.7  5.3  5.3  5.5  5.5  5.8  5.9   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  3.0  3.5  3.8  4.1  4.1  4.2  3.9  4.1
4.7  4.8  5.2  5.2  5.5  5.5  5.6   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  3.3  3.6  3.9  4.3  4.5  4.3  4.2  3.9  4.4
 4.5  5.0  5.0  5.0  5.2  5.3  5.4   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  3.7  4.2  4.5  4.6  4.8  4.7  4.3  4.2  4.4
 4.5  4.7  4.7  4.8  5.0  5.0  5.1   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  3.1  4.2  4.3  4.9  5.2  5.1  4.8  4.4  4.2
4.3  4.4  4.4  4.6  4.6  4.7  4.8  5.0   .0   .0
   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
 .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0  3.4  4.6  4.8  5.2  5.4  5.3  4.9  4.5  4.3
4.4  4.4  4.5  4.6  4.7  4.7  4.9  5.1   .0   .0
   .0   .0   .0   .0   .0   .6   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0   .0
```

```
.0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0 3.6 4.6 5.2 5.4 5.6 5.4 4.9 4.6 4.2
4.3 4.4 4.4 4.6 4.6 4.9 4.9 5.1  .0  .0
  .0  .0 1.3 1.9  .6 1.9  .0 1.9 2.7 2.8 2.9 2.8 2.8  .0  .0  .0  .0  .0  .0  .0
.0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0 3.7 4.7 5.6 5.7 5.6 5.3 4.9 4.5 4.4
4.4 4.4 4.5 4.5 4.8 4.8 5.0 5.0  .0  .0
  .0  .0 2.7 2.8 2.9 3.4 2.7 3.0 3.0 3.0 3.0 3.0 3.0 2.7 2.5  .0  .0  .0  .0
.0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0 3.9 5.1 5.6 5.7 5.5 5.2 4.9 4.5
4.3 4.4 4.4 4.6 4.6 4.6 4.9 4.9 5.1  .0  .0
  .0  .0 3.1 3.5 3.5 3.9 3.1 3.5 3.6 3.6 3.6 3.6 3.6 3.0 2.8 2.6  .0  .0  .0
.0  .6  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0 3.7 5.1 5.9 5.6 5.5 5.2 4.9 4.6
4.5 4.7 4.6 4.8 4.8 4.8 4.9 5.0 5.2  .0  .0
  .0  .0 3.5 4.0 4.0 4.4 3.7 4.1 4.1 4.1 4.1 4.1 4.1 3.6 3.3 3.0 2.8  .0 1.3
2.5 1.3  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0 5.3 5.1 5.5 5.5 5.1 4.9
4.7 4.6 4.7 4.9 4.9 4.9 4.9 4.9 5.1 5.3  .0  .0
  .0  .0 4.5 4.5 4.5 4.9 4.2 4.5 4.5 4.5 4.5 4.5 4.5 4.1 3.9 4.1 3.5 2.8 2.7
3.4 3.6 3.5 2.9 2.4  .0  .0  .0  .0  .0  .0  .0  .0  .0 3.8 5.0 5.0 5.3 5.1 4.8
4.8 4.8 5.0 5.3 5.4 5.4 5.4 5.4 5.4 5.4  .0  .0
  .0  .0 4.9 4.9 4.9 5.3 4.6 4.9 4.9 4.9 4.9 4.9 4.9 4.5 4.4 4.6 4.4 3.8 3.9
3.7 4.1 4.3 4.1 3.5 2.7  .0  .0  .0  .0  .0  .0  .0  .0 2.5 4.8 5.1 5.2 4.9 4.8
4.9 5.1 5.3 5.8 5.8 5.8 5.9 5.9 5.9 5.9  .0  .0
  .0  .0 5.3 5.3 5.4 5.7 5.0 5.4 5.4 5.4 5.4 5.4 5.3 5.0 4.7 4.9 4.7 4.4 4.5
4.5 4.3 4.7 4.6 4.2 3.4 2.8  .0  .0  .0  .0  .0  .0  .0  .0 3.7 4.5 4.9 4.6 4.7
4.9 5.1 5.4 5.8 6.1 6.1 6.1 6.1 6.0 6.0  .0  .0
  .0  .0 5.7 5.7 5.7 6.1 5.4 5.7 5.7 5.7 5.7 5.7 5.7 5.4 5.0 5.2 5.0 4.8 4.9
4.8 5.0 4.8 4.8 4.8 4.3 4.1 1.3  .0  .0  .0  .0  .0  .0  .0  .0 3.6 4.1 4.3 4.5
4.8 5.0 5.3 5.7 6.1 6.1 6.1 6.1 6.1 6.1  .0  .0
  .0  .0 6.1 6.1 6.1 6.6 5.8 6.2 6.2 6.2 6.2 6.1 6.1 5.8 5.4 5.2 5.2 5.0 5.1
5.5 5.0 5.0 5.0 4.7 4.4 3.5 1.3  .0  .0  .0  .0  .0  .0  .0 2.6 3.7 4.3 4.7 4.9
5.2 5.4 5.6 5.8 6.0 6.0 6.1 6.2 5.8 5.8  .0  .0
  .0  .0 6.6 6.6 6.6 6.8 6.2 6.6 6.6 6.6 6.6 6.6 6.6 6.2 5.7 5.5 5.3 5.1 5.4
5.7 5.5 5.1 4.9 4.7 4.3 3.5  .0  .0  .0  .0  .0  .0  .0  .0  .0 3.0 3.5 4.0 4.4
4.8 5.1 5.3 5.7 5.9 5.9 5.9 5.6 5.6 5.6  .0  .0
  .0  .0 6.8 6.8 6.9 7.2 6.7 6.9 6.9 6.9 6.9 6.8 6,8 6.6 6.2 5.4 5.5 5.4 5.6
5.6 5.5 5.1 4.9 4.7 4.4 3.8  .0  .0  .0  .0  .0  .0  .0  .0  .0 2.8 3.3 4.0 4.4
4.8 5.1 5.2 5.6 5.7 5.7 5.2 5.1 5.1 5.1  .0  .0
  .0  .0 7.2 7.3 7.3 7.5 7.0 7.3 7.3 7.2 7.1 7.0 7.0 7.0 6.3 5.6 5.5 5.4 5.7
5.6 5.4 5.1 5.0 4.7 4.5 4.0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0 2.7 3.4 3.9
4.3 4.7 5.1 5.4 5.3 4.8 4.6 4.6 4.6 4.7  .0  .0
  .0  .0 7.6 7.6 7.6 7.8 7.4 7.5 7.5 7.4 7.4 7.0 7.0 7.0 6.3 5.6 5.4 5.4 5.5
5.5 5.3 5.1 4.9 4.7 4.6 4.0 3.1  .0  .0  .0  .0  .0  .0  .0  .0  .0 2.6 3.4 3.9
4.4 4.7 4.5 4.5 4.2 3.9 4.1 4.3 4.4 4.5  .0  .0
  .0  .0 7.9 7.9 7.8 7.8 7.5 7.5 7.5 7.4 7.4 7.2 7.2 7.2 6.5 5.7 5.6 5.4 5.5
5.4 5.2 5.0 4.8 4.7 4.5 4.4 3.4  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0 2.6 3.3
3.9 4.6 4.1 3.8 3.4 3.6 3.7 4.0  .0  .0  .0  .0
  .0  .0 7.9 7.9 7.8 7.9 7.7 7.7 7.7 7.5 7.4 7.2 7.2 7.2 6.5 5.7 5.6 5.5 5.4
```

```
5.4  5.2  4.9  4.8  4.5  4.5  4.3  4.1  3.3   .0   .0   .0   .0   .0   .0   .0   .0   .0 2.6  3.3
4.0  4.6   .0   .0   .0   .0   .0 5.3  5.1   .0   .0   .0
   .0   .0  8.1  8.1  7.9  7.9  7.8  7.7  7.7  7.5  7.5  7.3  7.3  7.3  6.6  6.0  5.6  5.6  5.5
5.4  5.2  4.9  4.7  4.5  4.4  4.3  4.1  3.9  1.9   .0   .0   .0   .0   .0   .0   .0   .0 2.6  3.3
4.0  4.6  5.1  4.8  6.0  6.5  6.3  5.6  5.3   .0   .0   .0
   .0   .0  8.1  8.1  7.9  8.1  7.9  7.9  7.9  7.7  7.5  7.3  7.3  7.3  6.6  6.0  5.7  5.6  5.5
5.4  5.2  4.9  4.7  4.5  4.4  4.2  4.1  3.8  3.4   .0   .0   .0   .0   .0   .0   .0   .0 2.5  3.3
4.0  4.6  5.0  5.4  5.9  6.3  6.2  6.1  5.3   .0   .0   .0
   .0   .0  8.3  8.2  8.1  8.1  7.9  7.9  7.9  7.7  7.7  7.5  7.5  7.2  6.6  6.0  5.7  5.7  5.6
5.4  5.2  5.0  4.7  4.5  4.3  4.2  4.1  4.0  3.8  3.3   .0   .0   .0   .0   .0   .0   .0 2.5  3.3
4.0  4.5  4.6  5.3  5.8  6.3  6.1  5.9  5.9   .0   .0   .0
   .0   .0  7.9  7.9  7.8  7.9  7.7  7.6  7.6  7.5  7.4  7.2  7.2  7.1  6.4  5.7  5.8  5.7  5.6
5.5  5.2  4.9  4.7  4.4  4.3  4.1  4.0  4.0  3.8  3.6   .0   .0   .0   .0   .0   .0   .0 2.4  3.2
3.8  4.3  4.4  4.7  4.8  5.0  4.9  4.6  4.5  4.5   .0   .0
   .0   .0  7.7  7.7  7.6  7.6  7.4  7.4  7.3  7.2  7.2  7.0  6.8  6.7  6.0  5.8  5.8  5.8  5.7
5.5  5.3  5.0  4.7  4.4  4.2  4.0  4.0  4.0  3.9  3.7  3.3  2.5   .0   .0   .0   .0   .0 2.4  3.1
 3.6  4.1  4.4  4.5  4.7  4.8  4.5  4.1  3.8  4.1   .0   .0
   .0   .0  7.5  7.4  7.3  7.3  7.2  7.1  7.0  6.9  6.8  6.6  6.5  6.4  5.9  5.9  5.9  5.8  5.7
5.5  5.3  5.0  4.6  4.3  4.1  3.9  3.9  4.0  3.9  3.8  3.5  3.4  1.3   .0   .0   .0 1.3  2.8
3.4  3.8  4.2  4.5  4.5  4.6  4.6   .0 2.5  2.7  3.2   .0   .0
   .0   .0  7.2  7.3  7.2  7.2  6.9  6.8  6.7  6.6  6.5  6.3  6.2  6.0  5.9  5.9  5.9  5.8  5.7
5.5  5.3  5.0  4.7  4.3  4.0  3.9  3.9  3.9  3.9  3.8  3.6  3.4  2.5   .0   .0   .0 2.3  2.9
3.5  3.8  4.1  4.5  4.5  4.5  4.4   .0 2.2   .0 3.0   .0   .0
   .0   .0  7.0  6.9  6.8  6.7  6.5  6.4  6.4  6.2  6.1  5.9  6.0  6.0  6.0  6.0  5.9  5.9  5.8
5.6  5.3  5.0  4.7  4.4  4.2  3.9  3.9  3.9  3.8  3.8  3.6  3.4  2.5  1.3  1.3  1.3  4.3  4.5
4.8  5.0  5.0  5.2  4.7  4.5  4.1   .0 1.9  3.3  3.1   .0   .0
   .0   .0  6.6  6.5  6.4  6.4  6.2  6.0  6.0  5.8  5.9  6.0  6.0  6.0  6.0  6.0  6.0  5.9  5.8
5.6  5.3  5.1  4.8  4.5  4.2  3.8  3.9  3.8  3.8  3.7  3.6  1.3  1.3  3.1  3.5  4.3  4.2  4.3
4.5  4.7  4.7  4.8  4.3  4.3   .0   .0   .0 3.3  3.3   .0   .0
   .0   .0  6.2  6.2  6.1  6.0  5.8  5.7  5.8  5.9  6.0  6.0  6.1  6.1  6.1  6.0  6.0  5.9  5.8
5.6  5.4  5.1  4.8  4.5  4.2  4.0  3.9  3.8  3.8  3.7  3.6  4.0  4.0  4.0  4.0  4.1  4.1  4.2
4.2  4.2  4.2  4.1  3.9  3.8  3.7   .0   .0 3.4  3.4   .0   .0
   .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0
 .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0
 .0  .0  .0  .0  .0  .0  .0  .0
   .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0
 .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0  .0
 .0  .0  .0  .0  .0  .0  .0  .0
  1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
  1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
 1.0 5.1 5.1 5.1 5.1 5.1 5.1 5.1 5.0 4.9 4.9 4.8 1.0
  1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
```

```
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
7.7  7.8  9.8  9.8  9.8  9.9  9.9  9.9  9.9 10.0 10.0  4.6  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  7.7
7.8  7.8  7.8 10.4 10.4 10.4 10.4 10.5 10.5 10.5 10.6  4.4  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  5.0  7.7
7.8  7.8  7.7  7.7 10.3 10.3 10.4 10.4 10.5 10.6 10.9  4.3  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  5.1  6.3  7.1
9.1  9.4  8.1  8.6 10.0 10.1 10.1 10.2 10.2 10.5 10.6  4.1  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  5.3  6.3  7.1 10.0
10.0  9.8  8.1  8.5  9.3  9.3  9.9  9.9 10.2 10.2 10.3  4.1  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  8.0  6.7 11.1 10.0 10.0
10.0  9.6 10.0  9.2  9.2  9.8  9.8  9.7  9.9 10.0 10.0  4.1  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  6.7 11.1 11.1 11.1
10.0  9.2  9.6  9.0  9.1  9.4  9.5  9.5  9.6  9.7  9.7  9.8  4.0  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  5.5  7.7 11.1 11.1  9.2  9.4
9.7 10.0  8.9  9.0  9.1  9.1  9.3  9.3  9.4  9.5  9.7  4.0  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 11.1  8.3 11.1  9.3  9.7  9.9
10.4  9.6  9.4  9.3  9.3  9.4  9.5  9.6  9.6  9.8  9.9  3.8  1.0
 1.0  1.0  1.0  1.0  1.0  4.8  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 11.1  9.1  9.5  9.9 10.5 10.4
10.2  9.9 10.0  9.4  9.5  9.5  9.7  9.7  9.9  9.9 10.0  3.7  1.0
 1.0  5.2  5.1  8.2  5.1  8.2  1.0  5.1  8.2  8.2  8.2  8.2  8.2  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 11.1  9.7 10.1 10.4 10.6
10.3  9.9  9.5  9.8  9.7  9.6  9.7  9.7  9.9 10.0 10.1 10.2  3.5  1.0
 1.0  5.2  6.3  6.3  6.3  7.3  7.9  6.3  6.3  6.7  6.7  6.7  6.7  7.9  7.7  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  9.2 10.3 10.5 10.8 10.2
9.6  9.7  9.4  9.2  9.8  9.8  9.9 10.0 10.0 10.2 10.3 10.5  3.4  1.0
 1.0  5.3  7.3  7.3  7.3  8.1  6.7  7.4  7.4  7.4  7.4  7.4  7.4  6.7  6.3  6.7  1.0  1.0  1.0
1.0  4.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  6.2 10.0 10.9 10.3  9.9  9.4
9.6  9.3 10.1 10.2 10.1 10.2 10.3 10.3 10.4 10.6 10.7  3.7  1.0
 1.0  5.4  8.0  8.1  8.1  8.7  7.1  8.1  8.1  8.1  8.1  8.1  8.1  7.4  8.3  7.9  7.0  1.0  6.7
5.8  5.7  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 10.0 10.5  9.9  9.5  8.8
9.0  9.2  9.5  9.7 10.0 10.0 10.0 10.0 10.0 10.7 11.0  4.0  1.0
 1.0  5.4  8.7  8.7  8.7  9.3  8.1  8.7  8.7  8.7  8.7  8.7  8.7  8.1  8.9  8.9  8.2  7.4  5.6
7.2  7.3  7.3  6.1  6.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 10.0  9.9  9.6  8.9  8.3
8.6  9.0  9.4  9.7 10.1 10.3 10.3 10.3 10.3 10.3 10.3  4.4  1.0
 1.0  5.5  9.3  9.3  9.3  9.8  8.8  9.3  9.3  9.3  9.3  9.3  9.3  8.8  9.5  9.5  9.1  8.5  8.3
```

```
 7.1  8.3  8.4  8.3  7.5  7.5  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  6.2  7.7  8.7  8.5  7.7
8.4  8.9  9.3  9.7 10.5 10.5 10.5 10.6 10.6 10.6 10.6  4.8  1.0
  1.0  5.5  9.8  9.8  9.8 10.3  9.3  9.8  9.8  9.8  9.8  9.8  9.8  9.3 10.0 10.1  9.6  9.2
9.2  9.1  8.2  9.1  9.3  9.1  8.5  8.1  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0 10.0  8.6  8.4
7.7  8.4  8.9  9.3  9.7 10.3 10.7 10.7 10.7 10.7 10.7 10.7  4.9  1.0
  1.0  5.5 10.3 10.3 10.3 10.7  9.9 10.3 10.3 10.3 10.3 10.3 10.3  9.9  9.7 10.5 10.1
9.6  9.8  9.8  9.8  9.1  9.7  9.8  9.5  8.9  9.1  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  5.4
6.7  7.7  8.1  8.7  9.2  9.6 10.1 10.7 10.7 10.7 10.7 10.7 10.7  5.0  1.0
  1.0  5.5 10.7 10.7 10.7 11.1 10.3 10.7 10.7 10.7 10.7 10.7 10.7 10.3 10.1 10.6 10.3
9.9 10.2 10.4 10.4  9.8  9.8  9.8  9.7  9.5  2.9  1.0  1.0  1.0  1.0  1.0  1.0  1.0  6.1  7.1
7.8  8.3  8.8  9.3  9.6 10.0 10.3 10.6 10.7 10.7 10.9 10.4 10.4  5.1  1.0
  1.0  5.5 11.1 11.1 11.1 11.5 10.8 11.2 11.2 11.2 11.2 11.1 11.1 10.8 10.6 10.9 10.6
10.2 10.4 10.7 10.3  9.7  9.5  9.5  9.6  9.4  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
5.4  6.7  7.7  8.1  8.7  9.2  9.7 10.1 10.4 10.4 10.4  9.9  9.9  9.9  5.2  1.0
  1.0  5.5 11.5 11.5 11.5 11.9 11.2 11.5 11.5 11.5 11.5 11.5 11.5 11.2 11.0 11.0 10.9
10.6 10.7 10.6 10.1  9.4  9.4  9.4  9.3  9.2  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
5.4  6.7  7.7  8.1  8.7  9.1  9.5  9.9 10.0 10.0  9.3  9.3  9.3  9.3  5.3  1.0
  1.0  5.5 11.9 11.9 11.9 12.1 11.6 11.9 11.9 11.8 11.8 11.6 11.6 11.6 11.1 10.6 10.9
10.7 10.9 10.5  9.9  9.3  9.4  9.1  9.2  9.1  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
5.3  6.7  7.1  8.0  8.6  9.2  9.6  9.6  8.6  8.6  8.6  8.6  9.9  5.3  1.0
  1.0  5.5 12.2 12.2 12.2 12.3 11.9 12.1 12.1 11.9 11.9 11.6 11.6 11.6 11.1 10.6 11.0
10.8 10.8 10.3  9.8  9.2  9.1  9.1  9.1  8.9  8.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
5.3  6.7  7.1  8.0  8.6  9.1  9.1  7.7  7.8  9.6  7.7  9.6  9.6  5.4  1.0
  1.0  5.5 12.4 12.4 12.3 12.3 12.1 12.1 12.1 11.9 11.9 11.7 11.7 11.7 11.2 10.8 11.2
10.9 10.6 10.2  9.7  8.9  9.0  9.0  8.8  8.9 11.1  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  5.3  6.7  7.1  8.3  8.3  6.7  6.7  9.2  9.5  6.7  1.0  1.0  5.5  1.0
  1.0  5.5 12.4 12.4 12.3 12.4 12.2 12.2 12.1 12.0 11.9 11.7 11.7 11.7 11.2 10.8 11.0
10.9 10.4  9.9  9.3  9.1  8.9  8.7  8.8  8.6  8.7  8.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  5.3  6.7  7.1  8.3  1.0  1.0  1.0  1.0  1.0 10.9 10.4  1.0  5.5  1.0
  1.0  5.5 12.5 12.5 12.4 12.4 12.2 12.2 12.2 12.0 12.0 11.8 11.8 11.8 11.3 10.9 10.7
10.8 10.4  9.8  9.1  9.1  8.3  8.3  8.5  8.5  8.6  8.5 11.1  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  5.3  6.7  7.1  8.3  8.7  9.7 10.3 11.0 10.8 10.9 10.4  1.0  5.5  1.0
  1.0  5.5 12.5 12.5 12.4 12.4 12.3 12.2 12.2 12.1 12.0 11.8 11.8 11.8 11.3 10.9 10.7
10.6 10.1 11.1  9.1  8.3  8.3  8.3  8.3  8.3  8.3 11.1 11.1  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  5.3  6.7  7.1  8.3  8.7  9.5 10.2 10.8 10.4 10.6 10.4  1.0  5.5  1.0
  1.0  5.5 12.6 12.6 12.4 12.4 12.3 12.2 12.2 12.1 12.1 11.9 11.9 11.6 11.3 10.9 12.5
10.4 11.1 11.1 11.1  8.3  8.3  8.3  8.3  8.3  8.2 11.1  8.2  7.9  1.0  1.0  1.0  1.0  1.0
1.0  1.0  5.3  6.7  7.1  8.0  8.7  9.3 10.0 10.6 10.1 10.1 10.1  1.0  5.6  1.0
  1.0  5.5 12.2 12.2 12.1 12.2 12.0 12.0 11.8 11.8 11.5 11.5 11.4 11.4 10.8 12.5 12.5
12.5 12.5 12.5 11.1 12.5 12.5  7.7  8.3  7.7  6.2  6.2  6.2  6.2  1.0  1.0  1.0  1.0  1.0
1.0  1.0  5.2  6.3  7.1  7.9  8.5  9.1  9.7 10.3  9.5  9.4  7.7  8.3  5.6  1.0
  1.0  5.5 12.0 12.0 11.8 11.8 11.6 11.6 11.4 11.4 11.2 11.0 10.9 10.8 10.4 12.5 12.5
12.5 12.5 12.5 12.5 12.5 12.5 12.5  7.7  7.7  5.9  5.9  6.2  6.2  8.2  4.3  1.0  1.0  1.0
1.0  1.0  5.0  6.2  7.1  7.7  8.4  8.9  9.5 10.1  8.7  8.3  7.1  7.7  5.7  1.0
  1.0  5.5 11.7 11.6 11.4 11.4 11.2 11.0 11.0 10.8 10.8 10.6 10.4 10.4 12.5 12.5 12.5
```

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12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5  7.7  5.5  5.9  5.9  5.9  5.9  8.4  2.9  1.0  1.0
1.0  5.8  6.1  7.1  7.7  8.3  8.8  9.3  9.7 10.1  1.0  6.7  6.2  8.0  5.7  1.0
  1.0  5.5 11.4 11.3 11.1 11.1 10.9 10.7 10.7 10.5 10.3 10.2 10.0  9.8 12.5 12.5 12.5
12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5  7.7  5.1  5.5  5.5  5.5  5.5  8.6  5.5  1.0  1.0
1.0  4.8  6.0  6.7  7.7  8.3  8.7  9.1  9.6  9.6  1.0  5.8  1.0  7.8  5.8  1.0
  1.0  5.4 11.0 10.8 10.6 10.4 10.4 10.2 10.0  9.8  9.8 12.5 12.5 12.5 12.5 12.5 12.5
12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5  5.1  5.1  5.1  5.1  5.1  5.1  5.5  5.5  5.5
5.5  9.4  9.6  9.9 10.2 10.4 10.6 10.7 10.5  8.9  1.0  4.7  8.0  8.0  5.8  1.0
  1.0  5.3 10.4 10.4 10.1 10.0  9.8  9.6  9.4 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5
12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5  4.8  4.8  4.8  4.8  4.8  4.8  5.5  5.5  9.3  9.5
9.5  9.4  9.6  9.8 10.0 10.2 10.2 10.1 10.2  1.0  1.0  1.0  7.9  7.8  5.9  1.0
  1.0  5.3  9.9  9.8  9.8  9.5  9.3 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5
12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5 12.5  4.4  4.4  4.4  4.4  4.4  9.3  9.3  9.3  9.4
9.5  9.5  9.6  9.7  9.7  9.7  9.5  9.6  9.6  9.7  1.0  1.0  7.9  7.9  6.0  1.0
  1.0  5.2  5.2  5.2  5.2  5.2  5.3  5.3  5.4  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5
 5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5  5.5
5.5  5.5  5.5  5.5. 5.5  5.6  5.7  5.7  5.8  5.9  6.0  6.0  1.0
  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
 1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0  1.0
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
 0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
 0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.
   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
 0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0. 187. 183. 318. 325.
329. 329. 331. 335. 337. 338. 339.   0.   0.
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316. 321. 323. 326. 328. 329. 330. 331.   0.   0.
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320. 324. 317. 320. 322. 323. 324. 326.   0.   0.
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   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
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```

| | |
|---|---|
| NXTSTR.BN | Warm start data for next run. Saved with NSTR=1 or 3 in OPTIONS.DAT file. This file is unformatted. |
| BNDOUT.BN | Boundary data for next run. Saved with IBND=1 or 3 in OPTIONS.DAT file. This file is unformated. |
| FRCST.RST | Warm start data for forcast run. Saved with NHRSAV>0 in OPTION>DAT file. This file is un formatted. |

# APPENDIX 2

## Guide to Retrieving Forecast Wind Data

## Introduction

Forecast wind data required to operate the Florida Wave Forecast System can be acquired by FTP (file transfer protocol) from the NOAA Server at nic.fb4.noaa.gov(140.90.50.22); anonymous login allowed . Once this FTP site has been open the wind data can be found in the */pub/data.12z* and */pub/data.00Z* subdirectories. The files in these sub-directories contain essentially all of the National Meteorological Center's current observational data, analyses, and forecasts from the 00Z (UTZ) and 12Z cycles. The information is placed in these directories on an approximate 12-hour delayed basis and remains in place for approximately 24 hours. After 24 hours it is replaced with the then current data. These is no provision for the restoration of "old" data. It is the users responsibility to retrieved the data when it is "hot".

In documentation describing the content of the various data files, the file names are all indicated as starting with the characters "COM". For some reason the "COM" prefix is tripped of when the files are transferred from their original location to the NIC.

The forecast data are encoded into the World Meteorological Organization (WMO) Code GRIB (gridded binary) FM 92. The WMO manual described the GRIB and further documentation is provided on the NOAA NIC. Documentation on the NOAA.NIC can be found in */pub/nws/nmc.docs.* A README file identifies the contents of the documentation files. Directions finding and decoding forecast wind data in the GRIB format of the WMO can be found in subdirectory /pub/info/gribsun for the SUN Workstation environment and in subdirectory */pub/info/gribpc* for the PC environment . The GRIB decoder program, inventory program, and subroutines for unpacking grib files stored in the NOAA NIC file server are found in these subdirectories. The following section of Appendix 2 summarized the steps for using the GRIB decoder software to unpack wind forecast data in the Sun Workstation Environment. Although the Florida Wave Forecast System is being operation in the PC environment, data acquisition is much more convenient using the multitasking workstation platform

## Directions for Getting and Compiling GRIBSUN, the UNIX GRIB Decoder Sun Workstations Stations to Unpack Wind Forecast Data

### Getting the GRIB Decoder:

---

- Ftp the NOAA Server at nic.fb4.noaa.gov(140.90.50.22); anonymous login allowed.
- Change to the */pub/info/gribsun* directory.
- Switch to ASCII mode by typing *ASCII.*
- Turning prompting off by typing *prompt*(if desired), download the directory with *mget* *.*.

This downloads the executable shells which compile the Fortran77 source code for the GRIB decoder, as well as documentation, including the readme file README.SUN.

## Compiling the GRIB Decoder:

- Make the shells executable by typing *chmod +x *.sh* (this changes file permissions to be executable).
  for shells *comp*
- Change the f77 option *-cg92 to -xcg92* in a texteditor.*sh,compgo.sh,* and *compw31.sh*. This option can be confirmed by typing *fpversion.*
- Begin to compile by typing *compallg.sh*, the primary compiling shell which calls the other subroutines and places them in a library called *w3lib.a.*
- Verbose information follows while *compallg.sh* searches for the subroutines and, if it can't find them complies them.
- *listw3.sh* list the contents of *w3lib.a*. It should contain 18 **.o* files.
- Type in *comp.sh unpkgrb1* or *compgo.sh unpkgrb1*. This compiles the *unpkgrb1.f* and *unpkgrb1.x* and the other unpkgrb1 files except *unpkgrb1.dat*. (*comp.sh* and *compgo.sh* are almost identical.)
- *unpkgrb1.x* is the executable GRIB unpacker file.

## Decoding by running *unpkgrb1.x*

- Before *unpkgrb1.x* will run, it is necessary to create a file called *unpkgrb1.dat*. This file specifies the input file, the output file, and the format of the inputfile and actions you wish to specify during decoding.
- *unpkgrb1.dat* is most easily created in a text editor. It needs to consist of only two lines like this:

```
12030satwnd.t00z.ncbufr.gbl
map69_gbl.dat
```

  where *satwnd.t00z.ncbufr.gbl* is the coded input file, *map69_gbl.dat* is the decoded output file, and *12030* is a three-number options that identifies the file type and extraction method. The meanings of this three-number option is described in *unpkgrb1.f.*

- After completing *unpkgrb1.dat*, type in *unpkgrb.x* and the program will attempt to decode your file. It begins running by coming up with a header saying "GRIB Decoder has Begun. Compiled...." and continues with verbose information about the input file, grids and error codes. The error codes are also detailed in *unpkgrb1.f.*

## Documents and Sources of Documentation

- The primary source of information on the GRIB decoding process and BUFR compaction process is in the */pub/nws/nmc/docs* directory on the same server as the GRIB source code(nic.fb4.noaa.gov).

  This directory is further divided into subdirectories that deal with specific aspects of GRIB and the data available. The README file in */pub/nws/nmc/docs* provides a guide to these subdirectories.