Wave Data Processing Toolbox Manual

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1. Introduction

Researchers routinely deploy oceanographic equipment in estuaries, coastal nearshore environments, and shelf settings. These deployments usually include tripod-mounted instruments to measure a suite of physical parameters such as currents, waves, and pressure. Instruments such as the RD Instruments Acoustic Doppler Current Profiler (ADCP™), the Sontek Argonaut, and the Nortek Aquadopp™ Profiler (AP) can measure these parameters. The data from these instruments must be processed using proprietary software unique to each instrument to convert measurements to real physical values. These processed files are then available for dissemination and scientific evaluation. For example, the proprietary processing program used to process data from the RD Instruments ADCP for wave information is called WavesMon. Depending on the length of the deployment, WavesMon will typically produce thousands of processed data files. These files are difficult to archive and further analysis of the data becomes cumbersome. More imperative is that these files alone do not include sufficient information pertinent to that deployment (metadata), which could hinder future scientific interpretation.

This open-file report describes a toolbox developed to compile, archive, and disseminate the processed wave measurement data from an RD Instruments ADCP, a Sontek Argonaut, or a Nortek AP. This toolbox will be referred to as the Wave Data Processing Toolbox. The Wave Data Processing Toolbox congregates the processed files output from the proprietary software into two NetCDF files: one file contains the statistics of the burst data and the other file contains the raw burst data (additional details described below). One important advantage of this toolbox is that it converts the data into NetCDF format. Data in NetCDF format is easy to disseminate, is portable to any computer platform, and is viewable with public-domain freely-available software. Another important advantage is that a metadata structure is embedded with the data to document pertinent information regarding the deployment and the parameters used to process the data. Using this format ensures that the relevant information about how the data was collected and converted to physical units is maintained with the actual data. EPIC-standard variable names have been utilized where appropriate. These standards, developed by the NOAA Pacific Marine Environmental Laboratory (PMEL) (http://www.pmel.noaa.gov/epic/), provide a universal vernacular allowing researchers to share data without translation.

2. Limitations

- This Wave Data Processing Toolbox has been developed specifically for use with wave data from:
  - RD Instruments Workhorse ADCP
  - Sontek Argonaut
  - Nortek Aquadopp AP
- The user must provide metadata information in an ASCII-file with specific formatting (templates provided, see discussion below). This information is read from the ASCII file and written to the NetCDF files.
- Wave information must be output from the instrument's proprietary software in ASCII format (details described below).
- For the RD Instruments ADCP, the Wave Data Processing Toolbox assumes the instrument is equipped with the optional waves acquisition firmware.
- For the Sontek Argonaut, the Wave Data Processing Toolbox assumes the wave spectra collection package, Sontek *SonWave*, is installed for collection of wave frequency spectra data. The user must also specify the LONG data format and metric units during deployment setup for data output. The Wave Data Processing Toolbox does not include provisions for reading the SHORT data format at this time.

3. Software Prerequisites

It is expected that the user has obtained all the proprietary software and necessary files to process the data from their specific instrument. For example, this would include (but is not limited to) the user installing and running the RD Instruments WavesMon software package to process all wave data from the RD Instruments ADCP. Similarly, the user should install and run the ViewArgonaut software package for the Sontek Argonaut and the AquaPro software for the Nortek AP. This manual provides some suggested guidance on program settings for these proprietary software packages. However, the user is responsible for all processing and should consult the user's manual for their proprietary software to determine settings for their specific deployment.

The Wave Data Processing Toolbox described in this manual consists of a Matlab-based package of m-files written in The Mathworks Inc., Matlab® programming language. We assume users have installed The Mathworks Inc., Matlab® software on their operating system. Users must also have installed on their operating system the USGS NetCDF Toolbox. This toolbox was developed by Dr. Charles R. Denham and is freely available for download from: http://woodshole.er.usgs.gov/staffpages/cdenham/public_html/MexCDF/nc4ml5.html or http://mexcdf.sourceforge.net/.

NetCDF is the file-format of choice for the USGS due to its platform independence and relative ease of use. Remote users on any number of computer platforms have the ability to load and visualize NetCDF data with a wide variety of open-source software applications, which are freely-available on the World Wide Web.

For more information on NetCDF users are referred to http://my.unidata.ucar.edu/content/software/netcdf/index.html.

ncBrowse is a utility for visualization of NetCDF data. It is freely-available at http://www.epic.noaa.gov/java/ncBrowse/

The Wave Data Processing Toolbox has been tested exclusively with The Mathworks Inc., Matlab® Release 14, Version 7, Service Pack 3 on a Windows XP operating system.

4. Processing Overview

Proprietary Software Waves Processing

Each instrument measures and records time series of velocity and pressure and processes these time series via spectral analysis to provide estimates of directional and/or non-directional energy density spectra and wave parameters. The wave height provided is Hmo, which is 4x the square root of the area under the non-directional energy density spectrum. It typically corresponds closely to the significant wave height, which is the average of the highest 1/3 of the waves in a record.

Other reported parameters include the peak period, which is the period at which the energy density is maximized. If applicable, the peak wave direction is computed, which is the direction corresponding to the maximum energy in the directional spectrum. The direction is defined as that from which the wave is coming (nautical convention).

Each instrument manufacturer provides a software program for the user to extract measured wave data and to convert (process) the data to engineering units. For the RD Instruments ADCP this software is called WavesMon. For the Sontek Argonaut the software is called ViewArgonaut, and for the Nortek AP the software is called AquaPro. These programs convert the raw binary data files into a series of (typically ASCII) text files containing the time series of wave energy density spectra and wave parameters such as significant wave height, peak wave period, and peak wave direction.

We assume users are familiar with their instrument's proprietary software and will choose processing options that are specific to their project. However, the Wave Data Processing Toolbox assumes that users have saved all processed data to ASCII files. In this manual we include a detailed outline of the processing options chosen for

each instrument. However, the actual parameters that a user selects are expected to vary with their particular application.

Matlab® Processing

The Wave Data Processing Toolbox m-files load the output from the proprietary processing software into Matlab®. The toolbox contains provisions for the removal of out-of-water data collected during instrument deployment and recovery. No additional data quality editing is provided at this stage. The statistical wave parameters are converted into EPIC-standard variables and written to a NetCDF file for distribution and archiving. Additionally, for the RD Instruments ADCP and the Nortek AP, individual bursts of velocity and pressure are written to a NetCDF file for archiving.

5. Processing Waves Data – Step by Step Instructions

5.1 Install the Waves Data Processing System

The Wave Data Processing Toolbox m-files are packed in the file WVTOOLS.zip, Unpack the contents of this zip file to a directory on your operating system's hard drive. This will place a folder named WVTOOLS on your hard drive. The m-files for this toolbox reside in the sub-folders named RDI, Sontek, Nortek, and AddOns. Then start Matlab® and add the WVTOOLS directories to your Matlab® path.

If, for example, you unpacked the WVTOOLS folder to:

c:\MFILES\WVTOOLS

you should type the following at the Matlab® command prompt to add the WVTOOLS directories to your Matlab® path:

>> addpath(genpath('c:\MFILES\WVTOOLS'))

5.2 Directory Setup

Users should run the proprietary software for their instrument and the Wave Data Processing Toolbox m-files in a directory that contains the raw binary data file downloaded from their instrument. If a directory with this file already exists on your operating system's hard drive, we advise you to create a sub-directory and copy the instrument's raw binary file to this sub-directory. This will isolate processing of the waves data from other processing that might occur using the file. As an example below, we create a sub-directory named 'wavesmon' in which we run the WavesMon software package and the Wave Data Processing Toolbox m-files for the RD Instruments ADCP. The raw binary data file from this instrument is copied into this directory from the directory above, '7221wh'. Similarly, we would create sub-directories named 'viewarg' and 'aquapro' for the Sontek Argonaut and Nortek AP, respectively.

Thus: C:\7221wh is a directory with raw binary data file downloaded from your instrument

C:\7221wh\wavesmon is a subdirectory with a *copy* of the raw binary data file, a metadata file, processed data output from the instrument's proprietary software, and NetCDF data files that will be output by this Wave Data Processing Toolbox.

5.3 The Metadata File

Users should next create a metadata file and place it in the sub-directory created above in section 5.2. A metadata file is a simple text file containing important information regarding the collection of the data. For example, it will typically include the location, date, and time of data collection. This information is crucial for scientific data interpretation. Common metadata fields are described in Appendix I. The Wave Data Processing Toolbox is designed to read a metadata file that has specific formatting. These files are instrument-specific. We provide example metadata files for each instrument in the Wave Data Processing Toolbox package of m-files. The files include metaRDI.txt for the RD Instruments ADCP, metaNortek.txt for the Nortek Aquadopp AP and metaSontek.txt for the Sontek Argonaut. It is recommended that users copy the included metadata file for their instrument into the subdirectory created in section 5.2 and use it as a template for their metadata file.

Once the metadata file is created, users should run the proprietary software package specific to their instrument in order to obtain ASCII file output of processed wave measurements. Step-by-step instructions for the proprietary software are provided in sections 5.4 for the RD Instruments ADCP, in 5.5 for the Sontek Argonaut and in 5.6 for the Nortek AP. Included in these instructions are suggested processing options (where available) for each instrument.

5.4 Processing for an RD Instruments ADCP

The RD Instrument ADCP records three different types of time series from which wave properties may be computed: pressure, range to the surface along each of its four beams (i.e., water level), and orbital velocities of the surface waves taken from three bins nearest the surface in each of the four beams. It is possible to estimate non-directional wave energy spectra, and thus wave height and period, from any of the three time series, but the velocity time series are required for definition of the directional distribution of the wave energy.

The WavesMon software package processes the raw binary ADCP data file and produces a series of computed data files. Pressure time series are output to files named Pressyyyynnddhhmmssxx.txt, where Press is pressure, and the remaining characters are year (yyyy), month (nn), day(dd), hour (hh), minute (mm), second (ss), and milli-second (xx). Time series of the range to surface are output to files named Strkyyyynnddhhmmssxx.txt, whereas time series of orbital velocities are output to Velyyyynnddhhmmssxx.txt. The orbital velocity measurements are used to calculate directional wave spectra, which are saved in output files called DSpecyynnddhhmm.txt, where Dspec is directional spectra, and the remaining characters are year (yy), month (nn), day (dd), hour (hh), and minute (mm) of the sample average. Data from all three methods are used to compute non-directional spectra, which are saved in files called PSpecyynnddhhmm.txt, SSpecyynnddhhmm.txt, and VSpecyynnddhhmm.txt where the PSpec* are derived from the pressure measurements, SSpec* are derived from the range to surface measurements, and VSpec* are derived from the orbital velocity measurements. Time series of wave parameters such as significant wave height, peak wave period, and peak wave direction are output in a file called *_LogData.000.

Users are cautioned against re-running WavesMon in a directory in which WavesMon was previously run. Doing so creates an additional time series of wave parameters called *_LogData.001, rather than overwriting the previous time series. The Wave Data Processing Toolbox assumes WavesMon was run once in a directory and that only one time series file called *_LogData.000 exists in the directory. Users are referred to RD Instrument's Waves User's Guide and the RDI Waves Primer for detailed WavesMon processing instructions and information regarding WavesMon's various processing options.

5.4.1. Start WavesMon

Double-click the WavesMon icon on your desktop to start WavesMon. Alternatively click the start menu and select **all programs** then **RD Instruments** and then **WavesMon.**

In the WavesMon **File** menu select **New Setup**. Then select **Playback** in the **Choose a realtime or playback** dialogue and click **OK**. Click **OK** again if a **Tip** pops up.

In the **Save Setup As** dialog browse to the location of the directory you created during 'Directory Setup' in section 5.2. Then enter a filename for your setup file. We use a filename that corresponds to our mooring number and instrument, such as 722wh, where '722' is the mooring number and 'wh' is for Workhorse ADCP. This file name is added by default to the *_LogData.000 file that contains the time series of wave parameters (i.e. 722wh_LogData.000).

In the **Setup Playback** screen select **Advanced**. The **Setup Playback (Advanced)** screen should now appear.

5.4.2 Designate Input and Output Options

In the **Setup Playback (Advanced)** screen select the **Input** tab. On the **Input** screen select Browse, then select your raw binary adcp data file and click **Open**.

Next, select the **Output** (fig. 1) tab from the **Setup Playback (Advanced)** screen. Under **Processed Waves Data** make sure both **Processed Data** and **Save Processed Data to Text Files** are checked (*Required*). Also make sure the **Wave Log Format** is 5 (*Required*).

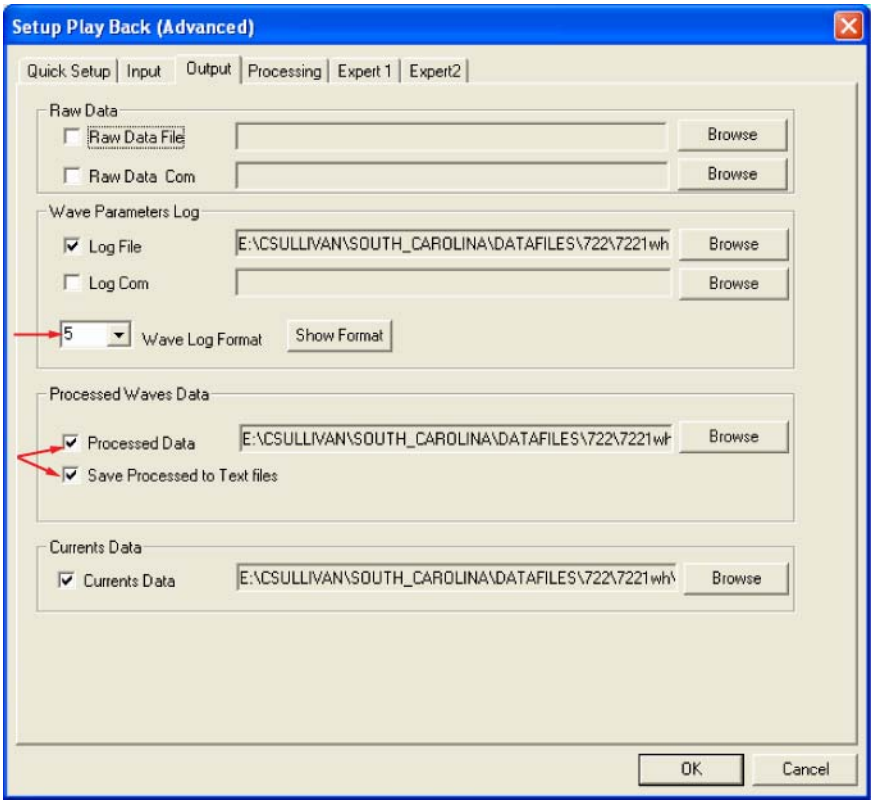


Figure 1: The Output tab from the WavesMon Setup Playback (Advanced) screen. Red arrows identify specific WavesMon processing options described in text.

5.4.3 Select Processing Options

Select the **Processing** (fig. 2) tab from the **Setup Playback (Advanced)** screen. Under **What to Process** make sure all boxes are checked. This will process and save the velocity, surface, and pressure time series and spectra, the directional spectra, and the wave parameters (*Required*). Under **How to Process** change **Lower Freq Threshold** from its default value (0.01) to 0.05. Change **Upper Freq Threshold** for velocity, **V**, from its default

value (0.35) to 0.5. Under **ADCP Environment** check the **Transducer Altitude** box and enter the transducer's altitude in centimeters. If your pressure sensor was working and was not significantly biofouled, be sure that **Pressure Sensor** is selected next to **Depth From.** Otherwise select **Surface Track.** Under **ADCP Heading** check the **Magnetic Variation** box and enter your location's magnetic variation in degrees. Magnetic variation is positive east of true north and negative when west

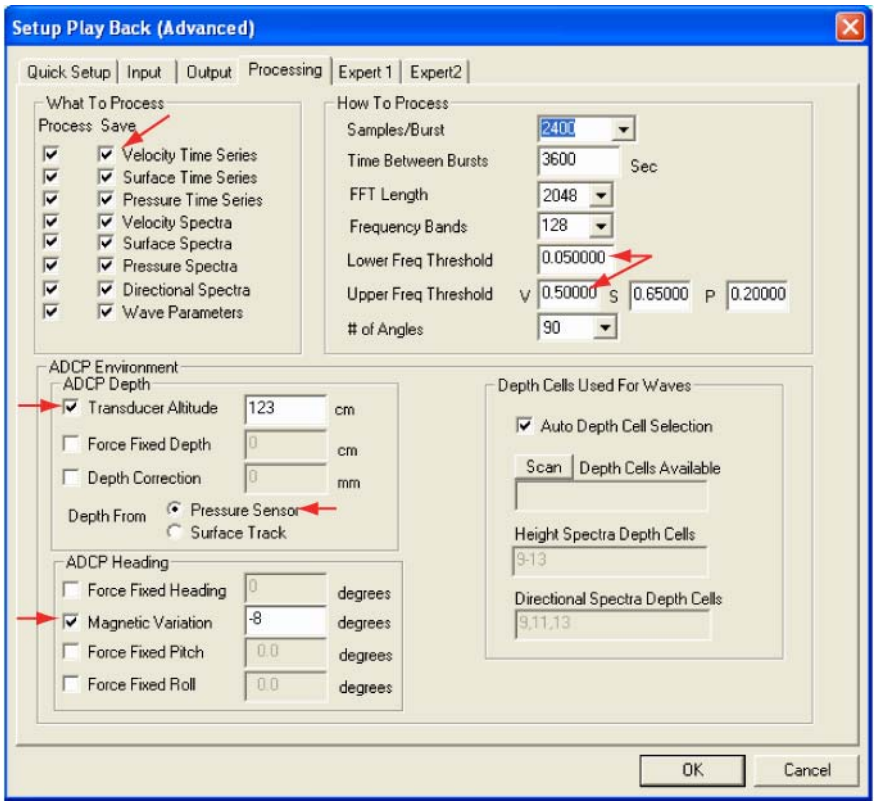
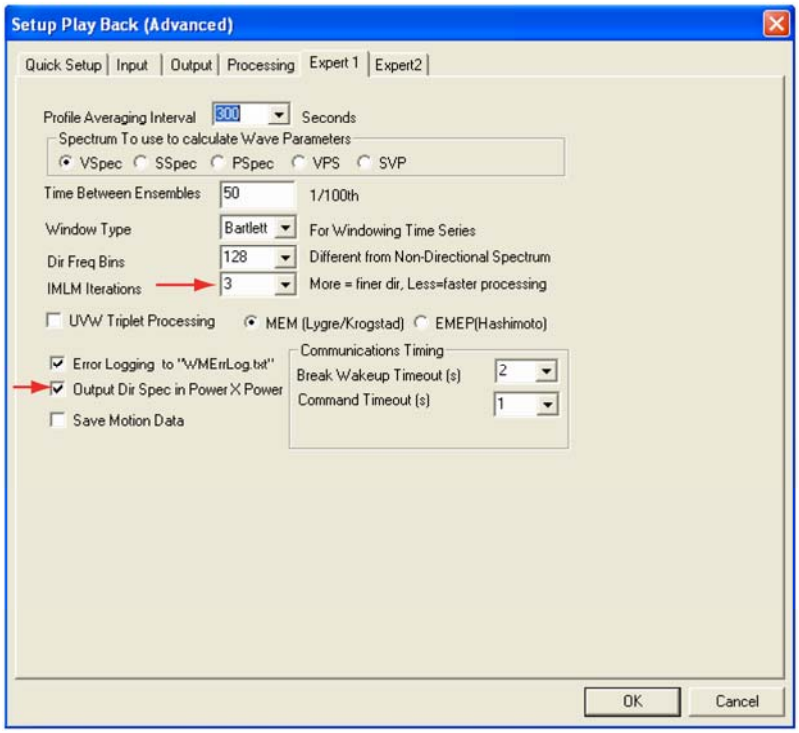


Figure 2: The Processing tab from the WavesMon Setup Playback (Advanced) screen. Red arrows identify specific WavesMon processing options described in text.

Next, select the **Expert 1** (fig. 3) from the **Setup Playback (Advanced)** screen. In the box next to **IMLM Iterations** click the **down** arrow to change the value from its default (1) to 3. Also check the box next to **Output Dir Spec in Power x Power** (*Required*).



Figue 3: The Expert 1 tab from the WavesMon Setup Playback (Advanced) screen. Red arrows identify specific WavesMon processing options described in text.

Lastly, select the **Expert 2** (fig. 4) from the **Setup Playback (Advanced)** screen. Under **Data Screening** check the box next to **Use File Buffer for Data.** Under **Misc** check the box next to **Correct for Currents.** Click **OK** to close the **Expert 2** tab. Click **OK** again to close the **Setup Playback (Advanced)** screen.

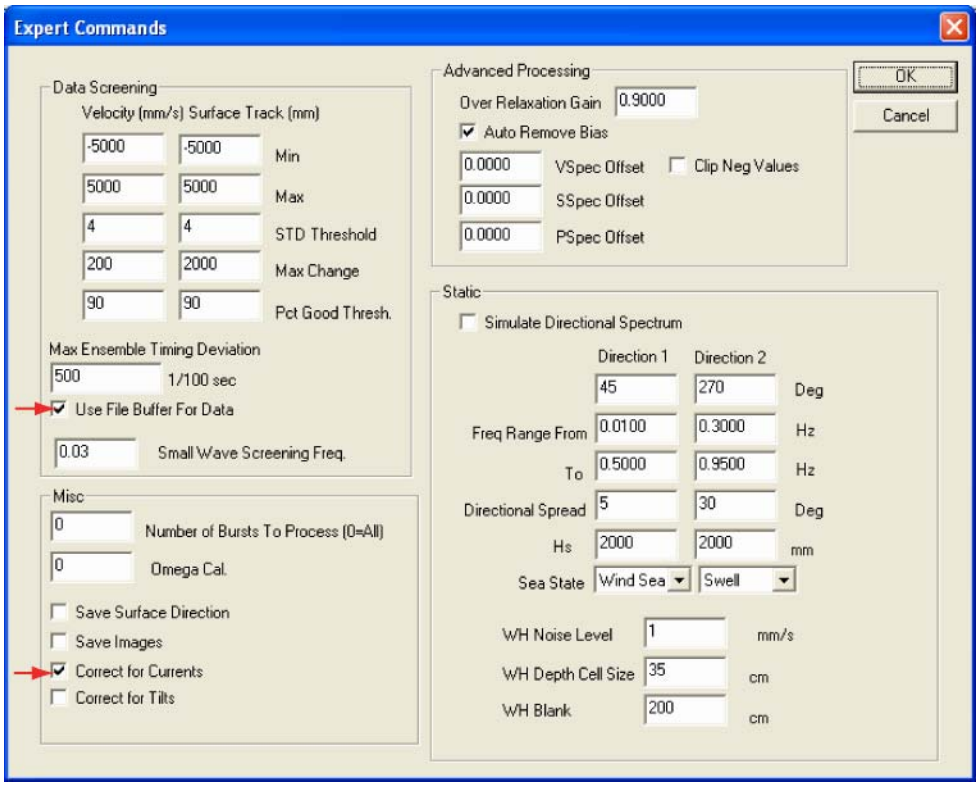


Figure 4: The Expert 2 tab from the WavesMon Setup Playback (Advanced) screen. Red arrows identify specific WavesMon processing options described in text.

5.4.4 Start WavesMon Processing

The **Setup Playback** screen should now be displayed. Select **OK** on this screen to close it. Select the green **Go** button on the main WavesMon screen to commence WavesMon processing. This processing produces the Press*.txt, Strk*.txt, Vel*.txt, DSpec*.txt, PSpec*.txt, VSpec*.txt, SSpec*.txt, and *_LogData.000 ASCII output files.

Once WavesMon has completed, the user should exit WavesMon and follow the step-by-step instructions outlined in section 5.7 to run the Waves Data Processing Toolbox.

5.5 Processing for a Sontek Argonaut

The Sontek Argonaut measures wave pressure and computes a non-directional wave energy spectra. The Waves Data Processing Toolbox assumes the user has specified the LONG data format with metric units during system configuration. It also assumes the user has the wave spectra collection package, Sontek *SonWave*, installed for collection of wave frequency spectra data. The software that is proprietary to the Sontek Argonaut is called ViewArgonaut. The pressure signal is used to estimate wave height.

ViewArgonaut is used to convert a raw binary data file (*.arg) from the instrument to ASCII text files. It produces output files called *.ctl, *.snr, *.std, *.vel, and *.dat, where '*' is the name given to your deployment when setting up the ADP for deployment. The file *.ctl is an ASCII file containing information on the system configuration, and the contents of the other data files. The files *.snr, *.std, and *.vel contain multi-cell (profiling) data output for all samples for all cells. The *.vel file includes the x- and y- components of mean velocity, and speed and direction of the mean current. The *.std file includes the standard error in x- and y- components of mean velocity. The *.snr file contains the signal to noise ratio and amplitude for each beam. The processed wave data is

written to the *.dat file and includes significant wave height, peak period, and non-directional wave energy spectra information.

5.5.1 Start ViewArgonaut

Double-click the ViewArgonaut icon on your desktop to start the application. In the ViewArgonaut menu select **Processing**.

5.5.2 Select Input

Next, select **File** then **Open.** In the open dialogue box browse to the directory created in section 5.2.0 that contains the raw binary file from the instrument. Select the file and select **Open**. A box with Argonaut File information is displayed. Preview the information and select **Ok**. It is now possible for the user to view different displays of processed data if they choose to do so.

5.5.3 Select Output

In order to generate ASCII files with processed data, the user must export processed data from ViewArgonaut. In ViewArgonaut's **File** menu select **Export Data**. In the **ASCII File Output** box under **Save Files to Path** be sure to save files to the same directory in which the raw binary file from the instrument resides (this will be the directory created in section 5.2). It is important to check this path as the software defaults to the directory specified in the previous ViewArgonaut session. Under **Output File Name** use the default, which should be the same as your input file name without the .arg file extension. Under **Samples** make sure **All Samples** is checked (this is the default).

5.5.4 Export Data

Select **Export All Variables** in the lower right corner of the **ASCII File Output** box. If a box pops up regarding discharge data click **ok** to resume exporting data. A box titled **Output Ascii File Messages** should be displayed. In that box should be three messages stating the configuration data, the time series data, and the multi-cell data were successfully written. Click **OK** in this box. Then click **Close** on the **ASCII File Output** box.

At this point the user should exit ViewArgonaut and follow the step-by-step instructions outlined in section 5.7 to run the Waves Data Processing Toolbox.

5.6 Processing for a Nortek AP

The Nortek AP measures wave pressure and near-bed velocities. The proprietary software for the Nortek AP is called AquaPro and is used to convert binary data files to ASCII text files. The software produces output files called *.a1, *.a2, *.a3, *.hdr, *.sen, *.v1, *.v2, *.v3, *.whd, and *.wad. The files *.v1, *.v2, and *.v3 contain current velocities in user-defined coordinates, which can be as beam coordinates, as orthogonal coordinantes in relation to the sensor head or as geographic coordinates. The files *.a1, *.a2, and *.a3 contain amplitudes along the instrument's three beams. Instrument set-up information is located in the *.hdr file. A summary of each burst is supplied in the file *.wad. Burst-by-burst data is provided in the file *.whd. The file *.sen, contains a summary of sensor information, such as instrument heading, pitch, roll, and battery voltage. The m-files in this Wave Data Processing Toolbox use the PUV method to estimate wave parameters. If current velocities were collected in beam coordinates, they will be converted to geographical coordinates by the toolbox prior to the application of the PUV method. The pressure signal is used to estimate wave height and the measurements of the waves' orbital velocities provide an estimate of the wave direction, after correction is performed for depth attenuation. Additional information is provided at:

http://www.nortek-as.com/technotes/PUVWaves.pdf

5.6.1 Start AquaPro

Double-click the AquaPro icon on your desktop to start the application.

5.6.2 Select Input

Under the **Deployment** menu, select **Data Conversion**. In the Data Conversion pop-up box, select **Add File**. Browse to the folder created in section 5.2 that contains the instrument's raw binary data file (*.prf). Select this file and then select **Open**.

5.6.3 Select Output

In order to generate ASCII files using processed data, the user must export processed data from AquaPro. In the **Data Conversion** box next to **Add prefix**, enter a character string that will be pre-pended to the output files.

5.6.4. Export Data

Select the blue arrow in the center of the **Data Conversion** box. In the Data Conversion pop-up box, there should be check marks next to the following boxes: Header, Velocity, Amplitude, Sensors, and Wave. Select **OK** to commence exporting of data. When processing is completed, the output file names will be displayed under **Converted files** in the **Data Conversion** box. Select **Done** and then close the AquaPro software. The *.a1, *.a2, *.a3, *.hdr, *.sen, *.v1, *.v2, *.v3, *.whd, and *.wad should now exist in the directory containing the instrument's raw binary data file.

At this point the user should exit AquaPro and follow the step-by-step instructions outlined in section 5.7 to run the Wave Data Processing Toolbox.

5.7 Matlab® Processing

5.7.1 Start Matlab®

Double-click the Matlab icon on your desktop to start Matlab®. Alternatively, click the start menu and select **all programs** then **Matlab** x.xx, **Matlab** x.xx where 'x.xx' is the version of Matlab® installed on your computer.

5.7.2 Change directories

At the Matlab command prompt change directories to the directory you created in section 5.2. This directory should contain the raw binary data file from the instrument, the metadata file, and the ASCII output files from your instrument's proprietary software. For example, the directory created in section 5.2 contains the raw binary data file from an RD Instruments ADCP, a metadata file, and WavesMon-generated ASCII output files. Type the following at Matlab's command prompt in order to change directories to this directory:

```
>> cd C:\7221wh\wavesmon
```

5.7.3 Run the Wave Data Processing Toolbox

The Wave Data Processing Toolbox is run by a driver m-file that calls a series of m-files (outlined below) to load proprietary software output files, to convert data into EPIC-compatible variables where appropriate, and to

convert data to NetCDF. These m-files were developed by the authors, but they include calls to other user-contributed m-files. We include all required m-files in the Wave Data Processing Toolbox package.

The driver m-files for the instruments supported by this package are called adcpWvs2nc.m (for the RD Instruments adcp), argnWvs2nc.m (for the Sontek Argonaut), and aqdpWvs2nc.m (for the Nortek AP). The inputs for these driver m-files include the metadata file name and a character string that represents the NetCDF file names to which data will be written. To run the Wave Data Processing Toolbox the user would type the following at Matlab's command prompt:

For the RD Instruments ADCP

```
>> adcpWvs2nc(metaFile, outFileRoot)
```

For the Sontek Argonaut

```
>> argnWvs2nc(metaFile, outFileRoot)
```

For the Nortek AP

```
>> aqdpWvs2nc(metaFile, outFileRoot)
```

The input metaFile is a character string that specifies the name of your metadata file. This should be surrounded by single quotes and specified without the file extension .txt. The input outFileRoot is a character string that specifies the name of the netCDF files to which you would like to write the data. This string should be surrounded by single quotes, and the NetCDF file extension, .nc, is not necessary.

The Wave Data Processing Toolbox consumes a large amount of computer memory when it accumulates data into multi-dimensional arrays. We suggest users have no other programs running on their system while running the toolbox, and use a clean start of Matlab to prevent Matlab out-of-memory errors. Users may also wish to turn their hardware acceleration off before running the toolbox.

For the RD Instruments ADCP, bad data screening and removal are accomplished internally by WavesMon. The entire time series of pressure, velocities, and wave parameters are converted to NetCDF and no user-interaction is required. However, for both the Sontek Argonaut and the Nortek Aquadopp AP, user-interaction is required. The user is asked to view a plot of pressures and velocities (for the Nortek), or wave parameters (for the Sontek), and decide the first and last good bursts of data. All data between the first and last good bursts is converted to NetCDF. This provision was included to exclude out-of-water data, collected during deployment and recovery of the instruments, from the NetCDF files.

The NetCDF files outFileRootr-cal.nc and outFileRootp-cal.nc will be written to the directory you created in section 5.2. The first NetCDF file contains the time series of pressure and velocities. Please note that this NetCDF file is created only for the RD Instruments ADCP and the Nortek AP. We do not create this NetCDF file for the Sontek Argonaut, as the pressure time series from which wave parameters and spectra are calculated is not output by ViewArgonaut. The second NetCDF file contains the statistical wave parameters, and these files are created for all 3 supported instruments. Please refer to Appendix II and Appendix III for a listing of variables in the burst and statistic NetCDF files, respectively. This completes wave data processing with the Wave Data Processing Toolbox.

6. Wave Data Processing Toolbox M-files

The m-files called by the Wave Data Processing Toolbox are outlined below. These m-files do NOT require editing. Please report all bugs to John Warner at mailto:hjcwarner@usgs.gov. The authors would like to acknowledge NortekUSA for the inclusion of their m-files, wds.m, hs.m, logavg.m, and wavek.m in this processing package. All of Nortek's m-files were downloaded from http://www.nortekusa.com/principles/Waves.html#MatlabToolkit. The mfiles hs.m, logavg.m, and wavek.m remain unmodified from their original form. The mfile wds.m contains one modification to prevent erroring in Matlab®. We would also like to acknowledge Dr. Richard P. Signell, who provided the functions julian.m, and gregorian.m.

6.1 M-files for RD Instruments ADCP

M-files called for the RD Instruments ADCP are located in the sub-folder RDI of the WVTOOLS folder that was downloaded and installed in section 5.1.0. The m-files are also provided in this manual in Appendix IV. An outline and a short description of each m-file are provided below.

A. adcpWvs2nc.m ~ Primary driver mfile, controls calls to other m-files

B. nccreate_adcpWvs.m ~ a function to create and define the raw and processed NetCDF files for RD Instruments ADCP wave data storage, archival, and dissemination

C. read_adcpWvs.m ~ a function to load the WavesMon data file *_LogData.000 containing the time series of wave parameters

D. ncwrite_adcpWvs.m ~ a function to write the time series of wave parameters to the processed NetCDF file

E. read_adcpWvs_spec.m ~ a function to load the WavesMon data files Dspec*.txt, Pspec*.txt, Sspec*.txt, and Vspec*.txt containing the time series of directional and non-directional wave energy spectra

F. ncwrite_adcpWvs_spec.m ~ a function to write the time series of directional and non-directional wave energy spectra to the processed NetCDF file

G. read_adcpWvs_raw.m ~ a function to load the WavesMon data files Press*.txt, Strk*.txt, and Vel*.txt containing the raw time series of pressure, range to surface track, and orbital velocity data

H. ncwrite_adcpWvs_raw.m ~ a function to write the raw time series of pressure, range to surface track, and orbital velocity data the raw NetCDF file

6.2 M-files for Sontek Argonaut

M-files called for the Sontek Argonaut are located in the sub-folder Sontek of the WVTOOLS folder that was downloaded and installed in section 5.1. The m-files are also provided in this manual in Appendix V. An outline and a short description of each m-file are provided below.

A. argnWvs2nc.m ~ Primary driver mfile, controls calls to other m files

B. get_meta_sontek.m ~ a function to load user-defined metadata and instrument setup information

C. nccreate_argnWvs.m ~ a function to create and define the raw and processed NetCDF files for Sontek Argonaut wave data storage, archival, and dissemination

D. read_argnWvs.m ~ a function to load the ViewArgonaut file *.dat containing the time series of wave parameters and non-directional wave energy spectra

E. ncwrite_argnWvs.m ~ a function to write the time series of wave parameters and non-directional wave energy spectra to the processed NetCDF file

6.3 M-files for Nortek AP

M-files called for the Nortek AP are located in the sub-folder Nortek of the WVTOOLS folder that was downloaded and installed in section 5.1. The m-files are also provided in this manual in Appendix VI. An outline and a short description of each m-file are provided below.

A. aqdpWvs2nc.m ~ Primary driver mfile, controls calls to other m files

B. get_meta_nortek.m ~ a function to load user-defined metadata and instrument setup information

C. wad2puv.m ~ a function to read the Nortek Aquadopp AP file *.wad, split the file into individual bursts, and perform PUV analysis

D. nccreate_aqdpWvs.m ~ a function to create and define the raw and processed NetCDF files for Nortek AP wave data storage, archival, and dissemination

E. ncwrite_aqdpWvs.m ~ a function to write the time series of wave parameters and non-directional wave energy spectra to the processed NetCDF file

F. ncwrite_aqdpWvs_raw.m ~ a function to write the time series of raw pressures and velocities to the raw NetCDF file

7. References

RD Instruments Waves Primer: Wave Measurements and the RDI ADCP waves array technique.
http://www.rdinstruments.com/waves.html.

SonTek/YSI Argonaut Acoustic Doppler Current Meter Technical Documentation.
http://www.sontek.com/product/sw/viewarg/viewargonaut.htm.

Aquadopp Current Meter User manual.
http://www.nortek-as.com/support/manuals/Aquadopp_Manual.pdf

PUV Wave Directional Spectra: How PUV Wave Analysis Works.
http://www.nortek-as.com/technotes/PUVWaves.pdf

Appendix I: Metadata

The metadata file contains information regarding the instrument and the deployment. Example metadata files with specific formatting are provided in the Wave Data Processing Toolbox for each instrument. See metaRDI.txt, metaNortek.txt, and metaSontek.txt. Users may copy and edit these files to suit their project needs, or create their own metadata files. Users may choose to add or remove metadata fields. However, they must keep in mind that the metadata field's description must start at column 20 and not exceed column 83 of the file. Example metadata fields are described below.

Metadata Field	Field Description	Example
Mooring	mooring identification number	'7201'
Deployment_date	date of instrument deployment	'28-Oct-2003'
Recovery_date	date of instrument recovery	'21-Jan-2004
INST_TYPE	type of instrument and instrument manufacturer	'RD Instruments ADCP'
history	NetCDF file history	'ADCP wave data processed with RDI WavesMon software'
DATA_SUBTYPE	description of data type	'MOORED'
DATA_ORIGIN	data originating institution	'USGS/WHSC'
COORD_SYSTEM	coordinate system of the data	'GEOGRAPHIC'
WATER_MASS	water mass flag used for EPIC contouring programs	'?'
POS_CONST	consistent position flag (1 = not consistent)	'0'
DEPTH_CONST	consistent depth flag (1 = not consistent)	'0'
WATER_DEPTH	water depth in meters	'11.3 M'
DRIFTER	drifter flag (=1 if drifter)	'0'
VAR_FILL	missing or bad data value identifier	'1.0000000409184788E35'
EXPERIMENT	experiment name	'Myrtle Beach'
PROJECT	project name	'South Carolina Coastal Erosion Study'
DESCRIPT	location and/or site of data collection	'Site 1 ADCP'
longitude	instrument location	'-78.7893'
latitude	instrument location	'33.6497'
FILL_FLAG	data fill flag (=1 if data has fill values)	'0'
COMPOSITE	number of pieces in composite series	'0'
magnetic_variation	degrees between magnetic and true north at data location	'-8.22'

Appendix II: Description of variables in the burst NetCDF file

The following tables list a description of the variables output to the burst NetCDF file (outFileRootr-cal.nc) for the RD Instruments ADCP and the Nortek AP. A burst NetCDF file is not created for the Sontek Argonaut. Time is stored in the variables 'time' and 'time2'. The variable 'time' contains the Julian Day where Julian Day 2440000 begins at 0000 hours on May 23, 1968. The variable 'time2' contains milliseconds (msec) for each Julian Day. These two variables can be combined as in (1) to yield the time of each observation in Julian Days.

$$jday = time + \left(time2 / 1000 / 24 / 3600\right) \quad (1)$$

For RDI ADCP:

Variable	Description	Units
time	Time in Julian Days	Julian Day
time2	Time in Julian Days	msec of each Julian Day
burst	Burst number	counts
lat	Latitude	degree_north
lon	Longitude	degree_east
sample	Sample number	counts
press	Pressure sensor derived depth	mm
strk	Along-beam surface track	mm
vel	Along-beam velocity	mm/s

For Nortek AP:

Variable	Description	Units
time	Time in Julian Days	Julian Day
time2	Time in Julian Days	msec of each Julian Day
burst	Burst number	counts
lat	Latitude	degree_north
lon	Longitude	degree_east
sample	Sample number	counts
hght_18	Height of the sea surface relative to sensor	m
u_1205	Eastward velocity	cm/s
v_1206	Northward velocity	cm/s
w_1204	Vertical velocity	cm/s
amp	Beam amplitude	counts

Appendix III: Description of variables in the statistic NetCDF file

The following tables list a description of the variables output to the statistic NetCDF file (outFileRootp-cal.nc) for the RD Instruments ADCP, the Nortek AP, and the Sontek Argonaut. Time is stored in the variables 'time' and 'time2'. The variable 'time' contains the Julian Day where Julian Day 2440000 begins at 0000 hours on May 23, 1968. The variable 'time2' contains milliseconds (msec) for each Julian Day. These two variables can be combined as in (1) above to yield the time of each observation in Julian Days.

For the RDI ADCP:

Variable	Description	Units
time	Time in Julian Days	Julian Day
time2	Time in Julian Days	msec of each Julian Day
burst	Burst number	counts
lat	Latitude	degree_north
lon	Longitude	degree_east
wh_4061	Significant wave height	m
wp_4060	Mean wave period	s
hght_18	Height of the sea surface relative to sensor	m
frequency	Frequency at the center of each frequency band	Hz
direction	Direction at the center of each direction slice	degrees True
mwh_4064	Maximum wave height	m
wp_peak	Peak wave period	s
wvdir	Peak wave direction from which waves are propagating	degrees True
dspec	Directional wave energy spectrum	mm^2/Hz/degree
pspec	Pressure-derived non-directional wave height spectrum	mm/sqrt(Hz)
sspec	Surface-derived non-directional wave height spectrum	mm/sqrt(Hz)
vspec	Velocity-derived non-directional wave height spectrum	mm/sqrt(Hz)

For the Sontek Argonaut:

Variable	Description	Units
time	Time in Julian Days	Julian Day
time2	Time in Julian Days	msec of each Julian Day
burst	Burst number	counts
lat	Latitude	degree_north
lon	Longitude	degree_east
wh_4061	Significant wave height	m
hght_18	Height of the sea surface relative to sensor	m
hght_std	Standard deviation of height of the sea surface	m
frequency	Frequency at the center of each frequency band	Hz

wp_peak	Peak wave period	s
pspec	Pressure-derived non-directional wave height spectrum	mm/sqrt(Hz)

For the Nortek AP:

Variable	Description	Units
time	Time in Julian Days	Julian Day
time2	Time in Julian Days	msec of each Julian Day
burst	Burst number	counts
lat	Latitude	degree_north
lon	Longitude	degree_east
wh_4061	Significant wave height	m
hght_18	Height of the sea surface relative to sensor	m
frequency	Frequency at the center of each frequency band	Hz
dfreq	Frequency band width	Hz
wp_peak	Peak wave period	s
wvdir	Peak wave direction from which waves are propagating	degrees True
spread	Peak spreading	degrees
pspec	Pressure-derived non-directional wave height spectrum	mm/sqrt(Hz)
vspec	Velocity-derived non-directional wave height spectrum	mm/sqrt(Hz)

Appendix IV: M-files for RD Instruments ADCP

```
function adcpWvs2nc(metaFile,outFileRoot)
% adcpWvs2nc.m  A driver M-file for post-processing RD Instruments
%               WavesMon wave data in Matlab.
%
%    usage:  adcpWvs2nc(metaFile,outFileRoot);
%
%        where:  metaFile    - a string specifying the ascii file in which
%                              metadata is defined, in single quotes
%                              excluding the .txt file extension
%                outFileRoot - a string specifying the name given to the
%                              NetCDF output files, in single quotes
%                              excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Science Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Toolbox Functions:
%   nccreate_adcpWvs.m
%   read_adcpWvs.m
%   ncwrite_adcpWvs.m
%   read_adcWvs_spec.m
%   ncwrite_adcpWvs_spec.m
%   read_adcpWvs_raw.m
%   ncwrite_adcpWvs_raw.m
%
% Add-on Functions:
%   julian.m
%   gregorian.m
%   gmin.m
%   gmax.m

% C. Sullivan   10/25/05,   version 1.1
% Provide user additional feedback regarding code execution. File extension
% on metadata file no longer required for the input 'metaFile'.
% C. Sullivan   06/09/05,   version 1.0
% This function assumes the user ran RD Instruments WavesMon
% software, output the WavesMon raw and processed data to text files, and
% created the file 'metaFile.dat' with important metadata. The function
% assumes you are in a directory with this data and the netcdf toolbox and
% the Wave Data Processing System toolbox exist on your Matlab path. Raw
% and processed data is written to individual netCDF files.  An integer
% fill value (-32768) is used for the spectra data and the raw data.
% Clear statements interspersed throughout mfiles prevent out of memory
% errors.


more off

version = '1.1';
```

```
tic

% Check inputs
if ~ischar(metaFile) || ~ischar(outFileRoot)
    error('File names should be surrounded in single quotes');
end

% Check existence of metadata file
l=ls([metaFile,'.txt']);
if isempty(l)
    error(['The metafile ',metaFile,'.txt does not exist in this
directory']);
end

% Check WavesMon output
if isempty(dir('*_LogData.*'))
    error(['WavesMon output does not exist in the directory ',pwd])
elseif length(dir('*_LogData.*')) > 1
    error('Only one *_LogData.* file is permitted by this toolbox')
elseif isempty(dir('*Spec*.txt'))
    error('WavesMon output must include spectra data as text files')
elseif isempty(dir('Strk*.txt'))
    error('WavesMon output must include raw Range to surface data')
elseif isempty(dir('Press*.txt'))
    error('WavesMon output must include raw pressure data')
elseif isempty(dir('Vel*.txt'))
    error('WavesMon output must include raw orbital velocity data')
end

% Create and define your netcdf files
nccreate_adcpWvs(metaFile, outFileRoot);

% Load timeseries data
[logData] = read_adcpWvs;

% Write timeseries data to NetCDF
ncwrite_adcpWvs(logData, outFileRoot);

clear logData

% Load spectra data
[specData] = read_adcpWvs_spec;

% Write spectra data to NetCDF
ncwrite_adcpWvs_spec(specData, outFileRoot);

clear specData

% Load raw data
[rawData] = read_adcpWvs_raw;

% Write raw data to NetCDF
ncwrite_adcpWvs_raw(rawData, outFileRoot);

clear rawData
```

```
function nccreate_adcpWvs(metaFile,outFileRoot)
% nccreate_adcpWvs.m  A function to create empty netCDF files that will
%                     store RD Instruments ADCP wave data.
%
%    usage:  nccreate_adcpWvs(metaFile,outFileRoot);
%
%        where:  metaFile    - a string specifying the ascii file in which
%                              metadata is defined, in single quotes
%                              excluding the .txt file extension
%                outFileRoot - a string specifying the name given to the
%                              NetCDF output files, in single quotes
%                              excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Science Center
% Woods Hole, MA 02543
% csullivan@usgs.gov

% C. Sullivan   03/28/06,   version 1.2
% Add EPIC keys for the variables: maximum wave height (new EPIC key 4064),
% peak wave period (use existing EPIC key 4063), and peak wave direction
% (use existing EPIC key 4062). Don't use EPIC keys for spectra variables,
% because EPIC isn't suited for the spectral domain.  Perhaps CF conventions
% are better suited?
% C. Sullivan   10/25/05,   version 1.1
% Provide user additional feedback regarding code execution. File extension
on
% metadata file no longer required in the input metaFile.  Changed DATA_TYPE
% attribute description to be consistent with the documentation.  Changed
% EPIC code and units on the variable lon to 502 and degree_east for
% consistency w/ longitude as specified in the metafile where west is
% negative. Add ADCP bin size attributes.  Add selected bins for dspec and
% vspec to attributes. Define direction variable for directional spectra.
% Re-define frequency variable.
% C. Sullivan   06/09/05,   version 1.0
% Now defining both a raw data and processed data NetCDF files.  Including
% all information from the waves configuration file as metadata.  Dimensions
% depth (=1), lat (=1), and lon (=1), beam (= 4), and beambin (=12) are
% hardwired.


version = '1.2';

ncr = netcdf([outFileRoot,'r-cal.nc'],'clobber');
ncp = netcdf([outFileRoot,'p-cal.nc'],'clobber');

% Gather and write NetCDF metadata
[userMeta, userMetaDefs] = textread([metaFile,'.txt'],'%s
%63c','commentstyle','shell');
userMetaDefs = cellstr(userMetaDefs);

[wvmnMeta, wvmnMetaDefs] = read_WavesMon_config;

write_adcpWvs_meta(ncr, userMeta, userMetaDefs, wvmnMeta, wvmnMetaDefs)
ncr.DATA_TYPE = ncchar('ADCP pressure and velocity timeseries');
ncr.VAR_DESC = ncchar('press:vel:strk');
```

```
write_adcpWvs_meta(ncp,userMeta, userMetaDefs, wvmnMeta, wvmnMetaDefs)
ncp.DATA_TYPE = ncchar('ADCP processed wave parameters and spectra');
ncp.VAR_DESC = ncchar('Hs:Tp:Dp:Hmax:Tm:dspec:pspec:sspec:vspec ');

% Define NetCDF dimensions
disp(['Defining NetCDF dimensions in ',outFileRoot,'r-cal.nc and ',...
       outFileRoot,'p-cal.nc'])
define_adcpWvs_dims(ncr);
define_adcpWvs_dims(ncp);

% Define NetCDF variables
disp(['Defining NetCDF variables in ',outFileRoot,'r-cal.nc and ',...
       outFileRoot,'p-cal.nc'])
disp(' ')
define_adcpWvs_vars(ncr);
define_adcpWvs_vars(ncp);

endef(ncr);
ncr=close(ncr);
endef(ncp);
ncp=close(ncp);

return

% --------- Subfunction: Gather WavesMon configuration data ------------- %
function [wvmnMeta,wvmnMetaDefs]=read_WavesMon_config;

    disp(' ')
    disp('Reading WavesMon configuration data ...')
    configFile = ls('*Wvs.cfg');
    ind = 1;
    fid = fopen(configFile,'r');
    while 1
        tline = fgetl(fid);
        eqpos = strfind(tline,'=');
        if ~isempty(eqpos)
            wvmnMeta{ind,1} = tline(1:eqpos-1);
            wvmnMetaDefs{ind,1} = tline(eqpos+1:end);
            %convert whitespace in wvmnMeta to underscores
            ws = find(isspace(wvmnMeta{ind})==1);
            wvmnMeta{ind}(ws) = '_';
            %convert parenthesis in parameter names to underscores
            op = strfind(wvmnMeta{ind},'(');
            wvmnMeta{ind}(op) = '_';
            cp = strfind(wvmnMeta{ind},')');
            wvmnMeta{ind}(cp) = '_';
            %convert commas in parameter names to underscores
            c = strfind(wvmnMeta{ind},',');
            wvmnMeta{ind}(c) = '_';
            %make sure no parameter name is longer than 63 characters
            %or Matlab complains
            if length(wvmnMeta{ind})>63
                wvmnMeta{ind} = wvmnMeta{ind}(1:63);
            end
            ind = ind + 1;
```

```
        end
        if ~ischar(tline), break, end
    end
    fclose(fid);

return

% --------- Subfunction: Write NetCDF metadata ------------------------- %
function write_adcpWvs_meta(nc, userMeta, userMetaDefs, wvmnMeta,
wvmnMetaDefs)

    for a=1:length(userMeta)
        theField = userMeta{a};
        theFieldDef = userMetaDefs{a};
        if str2num(theFieldDef)
            nc.(theField) = str2num(theFieldDef);
        else
            nc.(theField) = theFieldDef;
        end
    end

    for a=1:length(wvmnMeta)
        theField = wvmnMeta{a};
        theFieldDef = wvmnMetaDefs{a};
        if str2num(theFieldDef) & ~isequal(theField,'VSpecBins')
            nc.WavesMonCfg.(theField) = str2num(theFieldDef);
        else
            nc.WavesMonCfg.(theField) = theFieldDef;
        end
    end

return

% --------- Subfunction: Define NetCDF dimensions ---------------------- %
function define_adcpWvs_dims(nc)

    %common dimensions for both raw and processed NetCDF files
    nc('time') = 0;
    nc('lat') = 1;
    nc('lon') = 1;

    if strcmp(nc.DATA_TYPE(:),'ADCP processed wave parameters and spectra')
        %dimensions specific to processed NetCDF file
        nc('frequency') = nc.WavesMonCfg.NFreqBins(:);
        nc('direction')  = nc.WavesMonCfg.NDir(:);
    elseif strcmp(nc.DATA_TYPE(:),'ADCP pressure and velocity timeseries')
        %dimensions specific to raw NetCDF file
        nc('sample') = nc.WavesMonCfg.FFTLen(:);
        nc('beam') = 4; %ADCP has 4 beams
        nc('beambin') = 4*3; %WavesMon uses 3 bins for each beam
    end

return

% --------- Subfunction: Define NetCDF variables ----------------------- %
function define_adcpWvs_vars(nc)
```

```
%coordinate variables are the same for both the raw and
%processed NetCDF files
nc{'time'} = nclong('time');
nc{'time'}.FORTRAN_format = ncchar('F10.2');
nc{'time'}.units = ncchar('True Julian Day');
nc{'time'}.type = ncchar('EVEN');
nc{'time'}.epic_code = nclong(624);

nc{'time2'} = nclong('time');
nc{'time2'}.FORTRAN_format = ncchar('F10.2');
nc{'time2'}.units = ncchar('msec since 0:00 GMT');
nc{'time2'}.type = ncchar('EVEN');
nc{'time2'}.epic_code = nclong(624);

nc{'burst'} = nclong('time');
nc{'burst'}.FORTRAN_format = ncchar('F10.2');
nc{'burst'}.units = ncchar('counts');
nc{'burst'}.type = ncchar('EVEN');

nc{'lat'} = ncfloat('lat');
nc{'lat'}.FORTRAN_format = ncchar('F10.4');
nc{'lat'}.units = ncchar('degree_north');
nc{'lat'}.type = ncchar('EVEN');
nc{'lat'}.epic_code = nclong(500);

nc{'lon'} = ncfloat('lon');
nc{'lon'}.FORTRAN_format = ncchar('F10.4');
nc{'lon'}.units = ncchar('degree_east');
nc{'lon'}.type = ncchar('EVEN');
nc{'lon'}.epic_code = nclong(502);


if strcmp(nc.DATA_TYPE(:),'ADCP processed wave parameters and spectra')
    %Record variables for ONLY the processed data NetCDF file.
    %EPIC variables
    nc{'wh_4061'} = ncdouble('time','lat','lon');
    nc{'wh_4061'}.long_name=ncchar('Significant Wave Height (m)');
    nc{'wh_4061'}.generic_name=ncchar('wave_height');
    nc{'wh_4061'}.units=ncchar('m');
    nc{'wh_4061'}.epic_code=nclong(4061);
    nc{'wh_4061'}.FORTRAN_format=ncchar('F10.2');
    nc{'wh_4061'}.FillValue_ = ncfloat(1.0000000409184788E35);
    nc{'wh_4061'}.minimum = ncfloat(0);
    nc{'wh_4061'}.maximum = ncfloat(0);

    nc{'wp_4060'} = ncdouble('time','lat','lon');
    nc{'wp_4060'}.long_name=ncchar('Mean Wave Period (s)');
    nc{'wp_4060'}.generic_name=ncchar('wave_period');
    nc{'wp_4060'}.units=ncchar('s');
    nc{'wp_4060'}.epic_code=nclong(4060);
    nc{'wp_4060'}.FORTRAN_format=ncchar('F10.2');
    nc{'wp_4060'}.FillValue_ = ncfloat(1.0000000409184788E35);
    nc{'wp_4060'}.minimum = ncfloat(0);
    nc{'wp_4060'}.maximum = ncfloat(0);
```

```
        nc{'mwh_4064'} = ncdouble('time','lat','lon');
        nc{'mwh_4064'}.long_name=ncchar('Maximum Wave Height (m)');
        nc{'mwh_4064'}.generic_name=ncchar('wave_height');
        nc{'mwh_4064'}.units=ncchar('m');
        nc{'mwh_4064'}.epic_code=nclong(4064);
        nc{'mwh_4064'}.FORTRAN_format=ncchar('F10.2');
        nc{'mwh_4064'}.FillValue_ = ncfloat(1.0000000409184788E35);
        nc{'mwh_4064'}.minimum = ncfloat(0);
        nc{'mwh_4064'}.maximum = ncfloat(0);

        nc{'hght_18'} = ncdouble('time','lat','lon');
        nc{'hght_18'}.long_name=ncchar('Height of the Sea Surface (m)');
        nc{'hght_18'}.generic_name=ncchar('height');
        nc{'hght_18'}.units=ncchar('m');
        nc{'hght_18'}.epic_code=nclong(18);
        nc{'hght_18'}.FORTRAN_format=ncchar('F10.2');
        nc{'hght_18'}.NOTE=ncchar('height of sea surface relative to
sensor');
        nc{'hght_18'}.FillValue_ = ncfloat(1.0000000409184788E35);
        nc{'hght_18'}.minimum = ncfloat(0);
        nc{'hght_18'}.maximum = ncfloat(0);

        nc{'wp_peak'} = ncdouble('time','lat','lon');
        nc{'wp_peak'}.long_name=ncchar('Peak Wave Period (s)');
        nc{'wp_peak'}.generic_name=ncchar('wave_period');
        nc{'wp_peak'}.units=ncchar('s');
        nc{'wp_peak'}.epic_code=nclong(4063);
        nc{'wp_peak'}.FORTRAN_format=ncchar('F10.2');
        nc{'wp_peak'}.FillValue_ = ncfloat(1.0000000409184788E35);
        nc{'wp_peak'}.minimum = ncfloat(0);
        nc{'wp_peak'}.maximum = ncfloat(0);

        nc{'wvdir'} = ncdouble('time','lat','lon');
        nc{'wvdir'}.long_name=ncchar('Peak Wave Direction (degrees true
North)');
        nc{'wvdir'}.generic_name=ncchar('wave_dir');
        nc{'wvdir'}.units=ncchar('degrees T');
        nc{'wvdir'}.epic_code=nclong(4062);
        nc{'wvdir'}.FORTRAN_format=ncchar('F10.2');
        nc{'wvdir'}.NOTE=ncchar('Direction FROM which waves are propagating,
measured clockwise from true north');
        nc{'wvdir'}.FillValue_ = ncfloat(1.0000000409184788E35);
        nc{'wvdir'}.minimum = ncfloat(0);
        nc{'wvdir'}.maximum = ncfloat(0);

        %non-EPIC variables
        nc{'frequency'}=ncdouble('frequency');
        nc{'frequency'}.name=ncchar('freq');
        nc{'frequency'}.long_name=ncchar('Frequency (Hz)');
        nc{'frequency'}.generic_name=ncchar('frequency');
        nc{'frequency'}.units=ncchar('Hz');
        nc{'frequency'}.type = ncchar('EVEN');
        nc{'frequency'}.FORTRAN_format=ncchar('F10.2');
        nc{'frequency'}.NOTE=ncchar('frequency at the center of each
frequency band');
        nc{'frequency'}.minimum = ncfloat(0);
```

```
        nc{'frequency'}.maximum = ncfloat(0);

        nc{'direction'}=ncdouble('direction');
        nc{'direction'}.name=ncchar('dir');
        nc{'direction'}.long_name=ncchar('Direction (degrees T)');
        nc{'direction'}.generic_name=ncchar('direction');
        nc{'direction'}.units=ncchar('degrees T');
        nc{'direction'}.type = ncchar('EVEN');
        nc{'direction'}.FORTRAN_format=ncchar('F10.2');
        nc{'direction'}.NOTE=ncchar('direction at center of each direction
slice');
        nc{'direction'}.minimum = ncfloat(0);
        nc{'direction'}.maximum = ncfloat(0);

        nc{'dspec'}=ncshort('time','frequency','direction','lat','lon');
        nc{'dspec'}.name=ncchar('dspec');
        nc{'dspec'}.long_name=ncchar('Directional Wave Energy Spectrum
(mm^2/Hz/degree)');
        nc{'dspec'}.generic_name=ncchar('directional spectrum');
        nc{'dspec'}.units=ncchar('mm^2/Hz/degree');
        nc{'dspec'}.DspecBins=nc.WavesMonCfg.DirSpecBins(:);
        nc{'dspec'}.bin_size=nc.ADCPBinSize(:);
        nc{'dspec'}.FORTRAN_format=ncchar('F10.2');
        nc{'dspec'}.FillValue_ = ncshort(-32768);
        nc{'dspec'}.minimum = ncfloat(0);
        nc{'dspec'}.maximum = ncfloat(0);

        nc{'pspec'}=ncshort('time','frequency','lat','lon');
        nc{'pspec'}.name=ncchar('pspec');
        nc{'pspec'}.long_name=ncchar('Pressure-derived Non-directional Wave
Height Spectrum (mm/sqrt(Hz))');
        nc{'pspec'}.generic_name=ncchar('pressure spectrum');
        nc{'pspec'}.units=ncchar('mm/sqrt(Hz)');
        nc{'pspec'}.FORTRAN_format=ncchar('F10.2');
        nc{'pspec'}.FillValue_ = ncshort(-32768);
        nc{'pspec'}.minimum = ncfloat(0);
        nc{'pspec'}.maximum = ncfloat(0);

        nc{'sspec'}=ncshort('time','frequency','lat','lon');
        nc{'sspec'}.name=ncchar('sspec');
        nc{'sspec'}.long_name=ncchar('Surface-derived Non-directional Wave
Height Spectrum (mm/sqrt(Hz))');
        nc{'sspec'}.generic_name=ncchar('surface spectrum');
        nc{'sspec'}.units=ncchar('mm/sqrt(Hz)');
        nc{'sspec'}.FORTRAN_format=ncchar('F10.2');
        nc{'sspec'}.FillValue_ = ncshort(-32768);
        nc{'sspec'}.minimum = ncfloat(0);
        nc{'sspec'}.maximum = ncfloat(0);

        nc{'vspec'}=ncshort('time','frequency','lat','lon');
        nc{'vspec'}.name=ncchar('vspec');
        nc{'vspec'}.long_name=ncchar('Velocity-derived Non-directional Wave
Height Spectrum (mm/sqrt(Hz))');
        nc{'vspec'}.generic_name=ncchar('velocity spectrum');
        nc{'vspec'}.units=ncchar('mm/sqrt(Hz)');
        nc{'vspec'}.VspecBins=nc.WavesMonCfg.VSpecBins(:);
```

```
        nc{'vspec'}.bin_size=nc.ADCPBinSize(:);
        nc{'vspec'}.FORTRAN_format=ncchar('F10.2');
        nc{'vspec'}.FillValue_ = ncshort(-32768);
        nc{'vspec'}.minimum = ncfloat(0);
        nc{'vspec'}.maximum = ncfloat(0);

    elseif strcmp(nc.DATA_TYPE(:),'ADCP pressure and velocity timeseries')
        %Record variables for ONLY the raw data NetCDF file.  There are no
        %EPIC-compatible variables for these quantities.
        nc{'sample'} = nclong('sample');
        nc{'sample'}.FORTRAN_format = ncchar('F10.2');
        nc{'sample'}.units = ncchar('counts');
        nc{'sample'}.type = ncchar('EVEN');

        nc{'press'}=ncshort('time','sample','lat','lon');
        nc{'press'}.name=ncchar('press');
        nc{'press'}.long_name=ncchar('Pressure Sensor Derived Depth (mm)');
        nc{'press'}.generic_name=ncchar('pressure time series');
        nc{'press'}.units=ncchar('mm');
        nc{'press'}.FORTRAN_format=ncchar('F10.2');
        nc{'press'}.FillValue_ = ncshort(-32768);
        nc{'press'}.minimum = ncfloat(0);
        nc{'press'}.maximum = ncfloat(0);

        nc{'strk'}=ncshort('time','sample','beam','lat','lon');
        nc{'strk'}.name=ncchar('strk');
        nc{'strk'}.long_name=ncchar('Along-Beam Surface Track (mm)');
        nc{'strk'}.generic_name=ncchar('surface track time series');
        nc{'strk'}.units=ncchar('mm');
        nc{'strk'}.FORTRAN_format=ncchar('F10.2');
        nc{'strk'}.FillValue_ = ncshort(-32768);
        nc{'strk'}.minimum = ncfloat(0);
        nc{'strk'}.maximum = ncfloat(0);

        nc{'vel'}=ncshort('time','sample','beambin','lat','lon');
        nc{'vel'}.name=ncchar('vspec');
        nc{'vel'}.long_name=ncchar('Along-Beam Velocity (mm/s)');
        nc{'vel'}.generic_name=ncchar('velocity time series');
        nc{'vel'}.units=ncchar('mm/s');
        nc{'vel'}.bin_size=nc.ADCPBinSize(:);
        nc{'vel'}.FORTRAN_format=ncchar('F10.2');
        nc{'vel'}.FillValue_ = ncshort(-32768);
        nc{'vel'}.minimum = ncfloat(0);
        nc{'vel'}.maximum = ncfloat(0);

    end

return
```

```
function [logData]=read_adcpWvs
% read_adcpWvs.m  A function to load *LogData.000, which is output from RD
%                 Instrument's WavesMon software, and output the
%                 timeseries of wave parameters.
%
%   usage:  [logData]=read_adcpWvs;
%
%       where:  logData - a structure with the following fields
%                   file    - name of the *_LogData.* file
%                   burst   - burst number
%                   YY      - 2-digit year
%                   MM      - month
%                   DD      - day
%                   hh      - hours
%                   mm      - minutes
%                   ss      - seconds
%                   cc      - 1/100ths seconds
%                   Hs      - significant wave height, meters
%                   Hm      - maximum wave height, meters
%                   Tp      - peak wave period, seconds
%                   Tm      - mean wave period, seconds
%                   Dp      - peak wave direction, degrees true north
%                   ht      - water depth from pressure sensor, millimeters
%
% Written by Charlene Sullivan
% USGS Woods Hole Science Center
% Woods Hole, MA 02543
% csullivan@usgs.gov

% C. Sullivan   10/26/05,   version 1.1
% Provide user additional feedback regarding code execution.
% C. Sullivan   06/09/05,   version 1.0
% This function assumes you are in a directory with WavesMon-generated wave
% data and that the file *_LogData.000 exists in the directory.  Bad data
% indicator (-1) is replaced with NaN. Don't do time conversion to julian
% days in here. Do that conversion when writing the data to NetCDF.


version = '1.1';

% Load the *_LogData.* file
logFile = dir('*LogData*');
logData.file = logFile.name;
disp(['Reading statistical wave parameters from ',logData.file])
data = csvread(logData.file);

% Burst numbers
logData.burst = data(:,1);

% Extract time
logData.YY = data(:,2)+2000;
logData.MM = data(:,3);
logData.DD = data(:,4);
logData.hh = data(:,5);
logData.mm = data(:,6);
```

```
logData.ss = data(:,7);
logData.cc = data(:,8);

% Extract wave parameters
logData.Hs = data(:,9);
logData.Tp = data(:,10);
logData.Dp = data(:,11);
logData.ht = data(:,12);
logData.Hm = data(:,13);
logData.Tm = data(:,14);

% Replace all values of -1 (WavesMon bad data indicator
% for data is the *LogData.000 file) with NaN
theVars = {'Hs','Tp','Dp','ht','Hm','Tm'};
for v = 1:length(theVars)
    eval(['logData.',theVars{v},'(logData.',theVars{v},'== -1) = NaN;'])
end

return
```

```
function ncwrite_adcpWvs(logData,outFileRoot)
% ncwrite_adcpWvs.m  A function to write the timeseries of wave parameters,
%                    output from RD Instruments WavesMon software, to a
%                    netCDF file.
%
%   usage:  ncwrite_adcpWvs(logData,outFileRoot);
%
%       where:  logData - a structure with the following fields
%                   file    - name of the *_LogData.* file
%                   burst   - burst number
%                   YY      - 2-digit year
%                   MM      - month
%                   DD      - day
%                   hh      - hours
%                   mm      - minutes
%                   ss      - seconds
%                   cc      - 1/100ths seconds
%                   Hs      - significant wave height, meters
%                   Hm      - maximum wave height, meters
%                   Tp      - peak wave period, seconds
%                   Tm      - mean wave period, seconds
%                   Dp      - peak wave direction, degrees true north
%                   ht      - water depth from pressure sensor, millimeters
%               outFileRoot - name given to the processed data NetCDF file
%
% Written by Charlene Sullivan
% USGS Woods Hole Science Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Dependencies:
%   julian.m
%   gregorian.m
%   gmin.m
%   gmax.m

% C. Sullivan   03/29/06,   version 1.2
% Now using EPIC variable mwh_4064 for maximum wave height. Reverse the
% chronology on the history attribute so the most recent processing step is
% listed first.
% C. Sullivan   10/26/05,   version 1.1
% Provide user additional feedback regarding code execution.  Use NetCDF
% variable objects to handle statistical wave parameters.
% C. Sullivan   06/09/05,   version 1.0
% Do time conversion to julian days in here.  Calculate min/max values and
% replacing nan's with the NetCDF fill value.


version = '1.2';

% Convert time from gregorian to julian and get
% start_time, stop_time, and number of records
time = julian([logData.YY, logData.MM, logData.DD,...
               logData.hh, logData.mm, logData.ss+logData.cc/100]);
start_time=datenum([gregorian(time(1))]);
stop_time=datenum([gregorian(time(end))]);
```

```
nrec=length(time);

% Write coordinate variables to NetCDF
nc=netcdf([outFileRoot,'p-cal.nc'],'write');
nc{'time'}(1:nrec) = floor(time);
nc{'time2'}(1:nrec) = (time-floor(time)).*(24*3600*1000);
nc{'burst'}(1:nrec) = logData.burst;
nc{'lat'}(1) = nc.latitude(:);
nc{'lon'}(1) = nc.longitude(:);

% Write record variables to NetCDF
disp(' ')
disp(['Writing statistical wave parameters to ',outFileRoot,'p-cal.nc'])
ncnames = {'wh_4061','wp_4060','mwh_4064','wp_peak','wvdir','hght_18'};
names = {'Hs','Tm','Hm','Tp','Dp','ht'};
nNames = length(names);
for i = 1:nNames
    eval(['data = logData.',names{i},';'])
    if strcmp(names{i},'ht')
        data = data./1000;
    end
    eval(['nco = nc{''',ncnames{i},'''};'])
    nco.maximum = gmax(data);
    nco.minimum = gmin(data);
    theFillVal = nco.FillValue_(:);
    bads = find(isnan(data));
    data(bads) = theFillVal;
    nco(1:nrec) = data;
    disp(['Finished writing ',nco.long_name(:)])
end

% Add the following NetCDF global attributes
nc.WavesMonCfg.LogDataFile = ncchar(logData.file);
nc.CREATION_DATE = ncchar(datestr(now,0));
nc.start_time = ncchar(datestr(start_time,0));
nc.stop_time = ncchar(datestr(stop_time,0));

% Update the NetCDF history attribute
history = nc.history(:);
history_new = ['Statistical wave parameters converted to NetCDF by ',...
               'adcpWvs2nc:ncwrite_adcpWvs.m V ',version,' on ',...
               datestr(now,0),'; ',history];
nc.history = ncchar(history_new);

% Close NetCDF file
nc = close(nc);

disp(['Finished writing statistical wave parameters. ',...
       num2str(toc/60),' minutes elapsed'])

return
```

```
function [specData]=read_adcpWvs_spec
% read_adcpWvs_spec.m  A function to load a series of ASCII files, which
%                      are output from RD Instrument's WavesMon
%                      software, and output the directional and non-
directional
%                      wave energy spectra.
%
%   usage [specData]=read_adcpWvs_spec
%
%       where:  specData - a structure with the following fields
%                   dspec.data  - directional wave energy spectra,
mm^2/(Hz)/deg
%                   dspec.time  - dspec time, YYYYMMDDhhmm
%                   pspec.data  - pressure-derived non-directional wave
energy
%                                 spectra, mm/sqrt(Hz)
%                   pspec.time  - pspec time, YYYYMMDDhhmm
%                   sspec.data  - surface-derived non-directional wave energy
%                                 spectra, mm/sqrt(Hz)
%                   sspec.time  - sspec time, YYYYMMDDhhmm
%                   vspec.data  - velocity-derived non-directional wave
energy
%                                 spectra, mm/sqrt(Hz)
%                   vspec.time  - vspec time
%
% Written by Charlene Sullivan
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% Woods Hole, MA 02543
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% C. Sullivan   10/26/05,   version 1.1
% Provide the user additional feedback regarding code execution. Get the
% direction at the start of the first direction slice in order to create a
% vector that is direction.  This is useful for plotting the directional
% spectra.
% C. Sullivan   06/09/05,   version 1.0
% This function assumes you are in a directory with WavesMon-generated wave
% data and that the files D-,P-,S-,VSpec*.txt exist in the directory. Bad
% data (0) is replaced with NaN. Don't do time conversion to julian
% days in here. Do that conversion when writing the data to NetCDF.


version = '1.1';

disp(' ')
disp(['Reading wave energy spectra'])

% Spectra types
specType = ['D', 'P', 'S', 'V'];


for s = 1:length(specType)
    %get list of files for the spectra type
    D = dir([specType(s),'Spec*.txt']);
    nFiles = length(D);
```

```
    %loop through the files and load the data.  Also replace
    %all values of 0 (WavesMon bad data indicator for spectra
    %data) with NaN
    for n = 1:nFiles
        filename = D(n).name;

        if strcmp(filename(6),'0')
            filetime = str2num(filename(6:end-4)) + 200000000000;
        else
            filetime = str2num(filename(6:end-4)) + 190000000000;
        end

        switch specType(s)
            case 'D'
                if n == 1
                   %get the direction at which the first direction slice
                   %begins. this is determined by WavesMon and is the same
                   %throughout the deployment, but can vary between
                   %individual deployments
                   fid = fopen(filename,'r');
                   junk1 = fgetl(fid); junk2 = fgetl(fid); junk3 =
fgetl(fid);
                   junk4 = fgetl(fid); junk5 = fgetl(fid); info = fgetl(fid);
                   clear junk*
                   fclose(fid);
                   specData.Dspec.firstDirSlice = ...
                       sscanf(info', '%*s %*s %*s %*s %*s %*s %*s %d %*s');
                end
                data = textread(filename,'%n','headerlines',6);
                data( data == 0 ) = nan;
                specData.Dspec.time(n) = filetime;
                specData.Dspec.data(:,n)=data;
            otherwise
                data = textread(filename,'%n','headerlines',3);
                data( data == 0 ) = nan;
                eval(['specData.',specType(s),'spec.time(n) = filetime;'])
                eval(['specData.',specType(s),'spec.data(:,n)=data;'])
        end
    end
    disp(['Finished reading wave energy spectra from ',specType(s),...
          'Spec*.txt. '])
end

return
```

```
function ncwrite_adcpWvs_spec(specData, outFileRoot)
% ncwrite_adcpWvs_spec.m  A function to write the timeseries of directional
%                         and non-directional spectra, output from RD
%                         Instruments WavesMon, to a netCDF file.
%
%   usage:  ncwrite_adcpWvs_spec(specData, outFileRoot);
%
%       where:  specData - a structure with the following fields
%                   dspec.data  - directional wave energy spectra,
mm^2/(Hz)/deg
%                   dspec.time  - dspec time, YYYYMMDDhhmm
%                   pspec.data  - pressure-derived non-directional wave
energy
%                                 spectra, mm/sqrt(Hz)
%                   pspec.time  - pspec time, YYYYMMDDhhmm
%                   sspec.data  - surface-derived non-directional wave energy
%                                 spectra, mm/sqrt(Hz)
%                   sspec.time  - sspec time, YYYYMMDDhhmm
%                   vspec.data  - velocity-derived non-directional wave
energy
%                                 spectra, mm/sqrt(Hz)
%                   vspec.time  - vspec time
%               outFileRoot - name given to the processed data NetCDF file
%
% Written by Charlene Sullivan
% USGS Woods Hole Science Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Dependencies:
%   julian.m
%   gregorian.m
%   gmin.m
%   gmax.m

% C. Sullivan   03/29/06,   version 1.3
% Reverse the chronology on the history attribute so the most recent
% processing step is listed first. In calculating max and min attributes
% for the spectra, calculate the max and min over time for each frequency
% bin.
% C. Sullivan   03/08/06,   version 1.2
% The function no longer assumes the times of the spectra data include
% seconds. When aligning spectra data with wave parameters just use year,
% month, day, hour, and minute.
% C. Sullivan   10/26/05,   version 1.1
% Provide the user more feedback regarding code execution.  Define the
% variable direction for the directional spectra.  This direction is the
% direction at the center of each directional slice for the directional
% spectra.
% C. Sullivan   06/09/05,   version 1.0
% This function assumes times on the spectra data include the 30 seconds
% that the times in the *_LogData* files have.


version = '1.3';
```

```
nc = netcdf([outFileRoot,'p-cal.nc'],'write');

% Get dimensions from NetCDF file
theRecDim = nc('time');
nRec = size(theRecDim);
nRec = nRec(1);
theFreqDim = nc('frequency');
nFreq = size(theFreqDim);
nFreq = nFreq(1);
dFreq = 1/nFreq; % Frequency bands are 1/nFreq Hz wide
theDirDim = nc('direction');
nDir = size(theDirDim);
nDir = nDir(1);
dDir = 360/nDir; % Direction slices are nDir degrees wide

% Define a vector that is frequency.  This vector consists of the frequency
% at the CENTER of each frequency band.
frequency = [0:dFreq:dFreq*(nFreq-1)]';
frequency = (frequency + (frequency+dFreq))/2;

% Define a vector that is direction for the directional spectra.  This
% vector consists of the direction in the CENTER of each direction slice.
firstDir = specData.Dspec.firstDirSlice;
direction = [firstDir : dDir : dDir*(nDir-1)+firstDir]';
direction = (direction + (direction+dDir-1))/2;
f = find(direction > 360);
direction(f) = direction(f) - 360;

% Get time from the NetCDF file
nc_time = gregorian(nc{'time'}(:) + nc{'time2'}(:)/3600/1000/24);
nc_time = julian(nc_time);

% Write spectra data to the NetCDF file
disp(' ')
disp(['Writing wave energy spectra to ',outFileRoot,'p-cal.nc'])
theVars = var(nc);
for v = 1:length(theVars),
    if strcmp(ncnames(theVars{v}),'frequency')  || ...
       strcmp(ncnames(theVars{v}),'direction')  || ...
       strcmp(ncnames(theVars{v}),'dspec') || ...
       strcmp(ncnames(theVars{v}),'pspec') || ...
       strcmp(ncnames(theVars{v}),'sspec') || ...
       strcmp(ncnames(theVars{v}),'vspec')
            if strcmp(ncnames(theVars{v}),'frequency')
                % write frequency to NetCDF file
                theVars{v}(1:nFreq) = frequency;
                theVars{v}.minimum = gmin(frequency);
                theVars{v}.maximum = gmax(frequency);
            elseif strcmp(ncnames(theVars{v}),'direction')
                % write direction to NetCDF file
                theVars{v}(1:nDir) = direction;
                theVars{v}.minimum = gmin(direction);
                theVars{v}.maximum = gmax(direction);
            else
                if strcmp(ncnames(theVars{v}),'dspec')
                    % reshape the dspec data array so that
```

```
                    % rows is time, columns is frequency, and the
                    % 3rd dimension is direction. this time dimension
                    % differs from that in the NetCDF file, so I'm
                    % initializing another array to which I will later align
                    % (in time) the dspec data.
                    data_new = nan(nRec, nFreq, nDir);
                    sz = size(specData.Dspec.data);
                    for i = 1:sz(2)
                        temp = reshape(specData.Dspec.data(:,i), nDir,
nFreq)';
                        data(i,:,:) = temp;
                    end
                    spec_time = specData.Dspec.time';
                else
                    % reshape the p(s)(v)spec data arrays so that
                    % rows is time, and columns is frequency. this time
dimension
                    % differs from that in the NetCDF file, so I'm
                    % initializing another array to which I will later align
                    % (in time) the p(s)(v)spec data.
                    data_new = nan(nRec, nFreq);
                    spec = ncnames(theVars{v});
                    spec = upper(spec{1}(1));
                    eval(['data = specData.',spec,'spec.data'';'])
                    eval(['spec_time = specData.',spec,'spec.time'';']);
                end
                % convert times on the spectra from YYYYMMDDhhmm to
                % julian. then align the spectra data (in time) with the
                % time records in the NetCDF file. the time records in the
                % NetCDF file are based on times in the *LogData.000 file
                % (the wave parameters file).
                spec_time = YYYYMMDDhhmm2julian(spec_time);
                for rec=1:nRec
                    srec1 = find(spec_time>=nc_time(rec),1,'first');
                    dist1 = spec_time(srec1) - nc_time(rec);
                    srec2 = find(spec_time<=nc_time(rec),1,'last');
                    dist2 = nc_time(rec) - spec_time(srec2);
                    if ~isempty(srec1) && ~isempty(srec2)
                        if srec1 == srec2
                            srec = srec1;
                        elseif dist1 > dist2
                            srec = srec2;
                        elseif dist2 > dist1
                            srec = srec1;
                        elseif dist1 == dist2
                            srec = srec1;
                        end
                    else
                        srec = [];
                    end
                    if ~isempty(srec)
                        if strcmp(ncnames(theVars{v}),'dspec')
                            data_new(rec, :, :) = data(srec, :, :);
                        else
                            data_new(rec, :) = data(srec, :);
                        end
```

```
                    end
                end

                clear data spec_time

                % write the spectra data to NetCDF file and replace any
                % nans in the data with the NetCDF fill value
                if strcmp(ncnames(theVars{v}),'dspec')
                    theFillVal = theVars{v}.FillValue_(:);
                    bads = find(isnan(data_new));
                    data_new(bads) = nan;
                    theVars{v}.minimum = gmin(data_new(:));
                    theVars{v}.maximum = gmax(data_new(:));
                    data_new(bads) = theFillVal;
                    theVars{v}(1:nRec, 1:nFreq, 1:nDir) = data_new;
                else
                    theFillVal = theVars{v}.FillValue_(:);
                    bads = find(isnan(data_new));
                    data_new(bads) = nan;
                    theVars{v}.minimum = gmin(data_new);
                    theVars{v}.maximum = gmax(data_new);
                    data_new(bads) = theFillVal;
                    theVars{v}(1:nRec, 1:nFreq) = data_new;
                end
                theVar = char(ncnames(theVars{v}));
                disp(['Finished writing ',theVar])
                clear data_new
            end
    end
end

% Update the history attribute
history = nc.history(:);
history_new = ['Wave energy spectra converted to NetCDF by ',...
               'adcpWvs2nc:ncwrite_adcpWvs_spec V ',version,...
               ' on ',datestr(now,0),'; ',history];
nc.history = ncchar(history_new);

nc=close(nc);

disp(['Finished writing wave energy spectra. ',...
      num2str(toc/60),' minutes elapsed'])

return

% ------------------------ Subfunctions ---------------------------------- %
function [jd] = YYYYMMDDhhmm2julian(YYYYMMDDhhmm);

YYYY=floor(YYYYMMDDhhmm/100000000);
MM=floor((YYYYMMDDhhmm-YYYY.*100000000)./1000000 );
DD=floor((YYYYMMDDhhmm-(YYYY.*100000000)-(MM.*1000000))./10000);
hh=floor((YYYYMMDDhhmm-(YYYY.*100000000)-(MM.*1000000)-(DD.*10000))./100);
mm=floor((YYYYMMDDhhmm-(YYYY.*100000000)-(MM.*1000000)-(DD.*10000)-
(hh.*100)));

jd = julian([YYYY, MM, DD, hh, mm, zeros(size(YYYY))]);
```

```
return
```

```
function [burstData]=read_adcpWvs_raw
% read_adcpWvs_raw.m  A function to load Press*.txt, STrk*.txt, and
%                     Vel*.txt which is output from RD Instrument's
%                     WavesMon v. 2.01 software, and output the pressure,
%                     surface track, and velocity timeseries.
%
%   usage:  [burstData]=read_adcpWvs_raw;
%
%       where:  burstData - an structure w/ the following fields:
%                   burstData.press.data - the pressure timeseries,
%                   burstData.press.time - press time, YYYYMMDDhhmmsscc
%                   burstData.strk.data - the range-to-surface track
timeseries,
%                   burstData.strk.time - strk time, YYYYMMDDhhmmsscc
%                   burstData.vel.data - the velocity timeseries
%                   burstData.vel.time - vel time, YYYYMMDDhhmmsscc
%
% Written by Charlene Sullivan
% USGS Woods Hole Science Center
% Woods Hole, MA 02543
% csullivan@usgs.gov

% C. Sullivan   10/26/06,   version 1.1
% Provide the user more feedback regarding code execution.
% C. Sullivan   06/09/05,   version 1.0
% This function assumes you are in a directory with WavesMon-generated
% wave data and that the files Press*.txt, STrk*.txt, and Vel*.txt exist in
% the directory.


version = '1.1';

disp(' ')
disp('Reading pressure and velocity timeseries')

% Raw data types
rawType = {'Press', 'Strk', 'Vel'};

for s = 1:length(rawType)

    %get list of files for the raw data type
    D = dir([rawType{s},'*.txt']);
    nFiles = length(D);

    %loop through the files and load the data.
    for n = 1:nFiles
        filename = D(n).name;

        switch rawType{s}
            case 'Press'
                %load pressure timeseries
                filetime = str2num(filename(6:end-4));
                fid = fopen(filename,'r');
                fgetl(fid); fgetl(fid); fgetl(fid);
                data = fscanf(fid,'%f');
                burstData.press.time(n) = filetime;
```

```
                burstData.press.data(:,n) = int16(data);
                fclose(fid);

            case 'Strk'
                %load range-to-surface track timeseries
                filetime = str2num(filename(5:end-4));
                fid=fopen(filename,'r');
                fgetl(fid); fgetl(fid); fgetl(fid); fgetl(fid);
                data = fscanf(fid,'%f %f %f %f');
                burstData.strk.time(n) = filetime;
                burstData.strk.data(:,n) = int16(data);
                fclose(fid);

            case 'Vel'
                %load velocity timeseries
                filetime = str2num(filename(4:end-4));
                fid=fopen(filename,'r');
                fgetl(fid); fgetl(fid); fgetl(fid);
                fgetl(fid); fgetl(fid); fgetl(fid);
                data = fscanf(fid,'%f %f %f %f %f %f %f %f %f %f %f %f');
                burstData.vel.time(n) = filetime;
                burstData.vel.data(:,n) = int16(data);
                fclose(fid);
        end
    end
    disp(['Finished reading ',rawType{s}])

end

disp(['Finished reading pressures and velocities'])

return
```

```
function ncwrite_adcpWvs_raw(burstData, outFileRoot);
% ncwrite_adcpWvs_spec.m  A function to write the timeseries of raw data,
%                         output from RD Instruments WavesMon v. 2.01, to
%                         a netCDF file.
%
%   usage:  ncwrite_adcpWvs_raw(burstData, outFileRoot);
%
%       where:  burstData - an structure w/ the following fields:
%                   burstData.press.data - the raw pressure timeseries, mm
%                   burstData.press.time - time associated with pressure,
%                                          YYYYMMDDhhmmsscc
%                   burstData.strk.data - the raw range-to-surface track
%                                         timeseries, mm
%                   burstData.strk.time - time associated with range-to-
%                                         surface track, YYYYMMDDhhmmsscc
%                   burstData.vel.data - the raw velocity timeseries (mm/s)
%                   burstData.vel.time - time associated with velocity,
%                                        YYYYMMDDhhmmsscc
%               outFileRoot - name given to the raw data NetCDF file
%
% Written by Charlene Sullivan
% USGS Woods Hole Science Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Dependencies:
%   julian.m
%   gmin.m
%   gmax.m

% C. Sullivan   03/29/06,   version 1.2
% Reverse the chronology on the history attribute so the most recent
% processing step is listed first. In calculating max and min attributes,
% calculate the max and min over time for each frequency bin.
% C. Sullivan   10/26/05,   version 1.1
% Provide the user more feedback regarding code execution.
% C. Sullivan   06/09/05,   version 1.0
% Do time conversion to julian days in here.  Calculate min/max values. Do
% nothing with respect to replacing bad data values with fill values.
% This means the data in this raw data netcdf file is an exact
% representation of the data in the raw data ascii output files.


version = '1.2';

disp(' ')
disp(['Writing pressure and velocity timeseries to',...
       outFileRoot,'r-cal.nc'])

nc=netcdf([outFileRoot,'r-cal.nc'],'write');

% Get dimensions from NetCDF file
theRecDim = nc('time');
nRec = size(theRecDim);
nRec = nRec(1);
theSampleDim = nc('sample');
```

```
nSamples = size(theSampleDim);
nSamples = nSamples(1);
theBeamDim = nc('beam');
nBeams = size(theBeamDim);
nBeams = nBeams(1);
theBeamBinDim = nc('beambin');
nBeamBins = size(theBeamBinDim);
nBeamBins = nBeamBins(1);
clear *Dim

% Check raw data times, which ought to be equal
time_check = isequal(burstData.press.time, burstData.strk.time,
burstData.vel.time);
if true(time_check)
    raw_time = burstData.press.time';
    time = YYYYMMDDhhmmsscc2julian(raw_time);
    nRec = length(time);
    nc{'time'}(1:nRec) = floor(time);
    nc{'time2'}(1:nRec) = (time-floor(time)).*(24*3600*1000);
    clear raw_time time
else
    error('Times on raw data files should be the same')
end

% Define sample number
sample = [1:nSamples]';
nc{'sample'}(:) = sample;
clear sample

% Define burst number
burst = [1:nRec]';
nc{'burst'}(:) = burst;
clear burst

% Write lat/long to NetCDF file
nc{'lat'}(1)=nc.latitude(:);
nc{'lon'}(1)=nc.longitude(:);

% Write raw data to the raw data netCDF file
theVars = var(nc);
for v = 1:length(theVars),
    if strcmp(ncnames(theVars{v}),'press') || ...
       strcmp(ncnames(theVars{v}),'strk') || ...
       strcmp(ncnames(theVars{v}),'vel')
            theVar = char(ncnames(theVars{v}));
            eval(['data = burstData.',theVar,'.data;'])
            for rec = 1:nRec
                switch theVar
                    case 'press'
                        % reshape the press array so that
                        % rows is time and columns is sample
                        theVars{v}(rec, 1:nSamples) = data(:,rec)';
                        burstData.press.data = [];

                    case 'strk'
                        % reshape the strk array so that
```

```
                        % rows is time, columns is sample, and
                        % the 3rd dimension is number of beams (4)
                        temp = reshape(data(:,rec), nBeams,
length(data(:,rec))/nBeams)';
                        theVars{v}(rec, 1:nSamples, 1:nBeams) = temp;
                        clear temp
                        burstData.strk.data = [];

                    case 'vel'
                        % reshape the vel array so that
                        % rows is time, columns is sample, and
                        % the 3rd dimension is number of beams (4)
                        % times number of bins used for waves (3),
                        % ergo, nBeamBins=12
                        temp = reshape(data(:,rec), nBeamBins,
length(data)/nBeamBins)';
                        theVars{v}(rec, 1:nSamples, 1:nBeamBins) = temp;
                        clear temp burstData
                        burstData.vel.data = [];

                    end
            end
            disp(['Finished writing ',theVar])
    end
end

% Calculate min/max values
calc_min_max_vals(nc);

% Update the history attribute
history = nc.history(:);
history_new = ['Pressure and velocity timeseries converted ',...
               'to NetCDF by adcpWvs2nc:ncwrite_adcpWvs_raw.m V ',...
               version,' on ',datestr(now,0),'; ',history];
nc.history = ncchar(history_new);

nc=close(nc);

disp(['Finished writing pressure and velocities. ',...
       num2str(toc/60), ' minutes elapsed'])

return


% ------------------------ Subfunctions --------------------------------- %
function [jd] = YYYYMMDDhhmmsscc2julian(YYYYMMDDhhmmsscc)

YYYY=floor(YYYYMMDDhhmmsscc/1000000000000);
MM=floor((YYYYMMDDhhmmsscc-YYYY.*1000000000000)./10000000000 );
DD=floor((YYYYMMDDhhmmsscc-(YYYY.*1000000000000)-
(MM.*10000000000))./100000000);
hh=floor((YYYYMMDDhhmmsscc-(YYYY.*1000000000000)-(MM.*10000000000)-
(DD.*100000000))./1000000);
mm=floor((YYYYMMDDhhmmsscc-(YYYY.*1000000000000)-(MM.*10000000000)-
(DD.*100000000)-(hh.*1000000))./10000);
```

```
sec=floor((YYYYMMDDhhmmsscc-(YYYY.*1000000000000)-(MM.*10000000000)-
(DD.*100000000)-(hh.*1000000)-(mm.*10000))./100);
hsec=floor((YYYYMMDDhhmmsscc-(YYYY.*1000000000000)-(MM.*10000000000)-
(DD.*100000000)-(hh.*1000000)-(mm.*10000)-(sec.*100))); %1/100ths second

jd = julian([YYYY, MM, DD, hh, mm, sec+(hsec/100)]);

return

function calc_min_max_vals(nc)

theVars = var(nc);
for v = 1:length(theVars),
    if strcmp(ncnames(theVars{v}),'press') || ...
            strcmp(ncnames(theVars{v}),'strk') || ...
            strcmp(ncnames(theVars{v}),'vel')
        % calculate min/max values
        data = theVars{v}(:);
        theVars{v}.minimum = min(data);
        theVars{v}.maximum = max(data);
        clear data
    end
end

return
```

Appendix V: M-files for Sontek Argonaut

```
function argnWvs2nc(metaFile,outFileRoot);
% argnWvs2nc.m  A driver m-file for post-processing wave data from a
%               Sontek Argonaut.
%
%    usage:  argnWvs2nc(metaFile,outFileRoot);
%
%        where:  metaFile    - a string specifying the ascii file in which
%                              metadata is defined, in single quotes
%                              excluding the .txt file extension
%                outFileRoot - a string specifying the name given to the
%                              NetCDF output files, in single quotes
%                              excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Toolbox Functions:
%   get_meta_sontek.m
%   nccreate_argnWvs.m
%   read_argnWvs.m
%   ncwrite_argnWvs.m
%
% Add-on Functions:
%   julian.m
%   gregorian.m
%   gmin.m
%   gmax.m

% C.Sullivan    11/02/05,   version 1.1
% Provide user additional feedback regarding code execution. File extension
% on metadata file no longer required for the input 'metaFile', but the
% metadata file must be a text file w/ the .txt file extension. Remove
% isunix loop b/c dir works on both Unix and Windows.
% C. Sullivan   06/01/05,   version 1.0
% This Argonaut component of the Wave Data Processing System toolbox only
% writes a processed data NetCDF file, as the 1 hz pressure timeseries
% from which wave parameters are calculated, is not output by ViewArgonaut.


more off

version = '1.1';

tic

% Check that input and output file names are characters
if ~ischar(metaFile) || ~ischar(outFileRoot)
    error('Input and output file names should be surrounded in single
quotes');
```

```
end

% Check existence of metadata file and ViewArgonaut output.
l = dir([metaFile,'.txt']);
if isempty(l)
    error(['The metafile ',metaFile,'.txt does not exist in this
directory']);
end

ctl = dir('*.ctl');
if isempty(ctl)
    error(['ViewArgonaut output files do not exist in this directory'])
else
    ctlFile = ctl.name;
    datFile = [ctlFile(1:end-4),'.dat'];
end

% Gather user-defined and instrument metadata
[userMeta, argnMeta] = get_meta_sontek(metaFile, ctlFile);

% Create and define your netcdf file
nccreate_argnWvs(userMeta, argnMeta, outFileRoot);

% Load data
[argnData]=read_argnWvs(datFile);

% Write data to netcdf file
ncwrite_argnWvs(argnData, outFileRoot);
```

```
function [userMeta, argnMeta] = get_meta_sontek(metaFile, ctlFile);
% get_meta_sontek.m  A function to load user-defined metadata and
%                    instrument setup parameters from a Sontek Argonaut.
%
%   usage:  [userMeta, argnMeta] = get_meta_sontek(metaFile, ctlFile);
%
%       where:  metaFile - a string specifying the ascii file in which
%                          metadata is defined, in single quotes
%                          excluding the .txt file extension
%               ctlFile - a string specifying the ascii file in which
%                         Argonaut setup parameters are defined, in single
%                         quotes including the file extension .ctl
%                         which contains Argonaut setup parameters
%               userMeta - a structure with user-defined metadata
%               argnMeta - a structure with Argonaut setup parameters
%
% Written by Charlene Sullivan
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% Woods Hole, MA 02543
% csullivan@usgs.gov

% C. Sullivan   11/02/05,   version 1.1
% Metadata file must be a .txt file.  The .txt extension is not required in
% the input 'metaFile'. Provide the user additional feedback regarding code
% execution.
% C. Sullivan   05/31/05,   version 1.0
% This function is coded to read a user-defined metadata file with specific
% formatting.  See the toolbox documentation for more information. It is
% assumed that the comments in the Argonaut's .hdr file occupy no more than
% 3 lines.


version = '1.1';

% Gather user-defined metadata
disp(' ')
disp('Reading user metadata')
[atts, defs] = textread([metaFile,'.txt'],'%s %63c','commentstyle','shell');
defs = cellstr(defs);
for i = 1:length(atts)
    theAtt = atts{i}(:)';
    theDef = defs{i}(:)';
    %deblank removes trailing whitespace
    theAtt = deblank(theAtt);
    theDef = deblank(theDef);
    %check for and replace spaces in
    %the attributes with underscores
    f1 = find(isspace(theAtt));
    f2 = strfind(theAtt,'-');
    f = union(f1,f2);
    if ~isempty(f)
        theAtt(f) = '_';
    end
    %attribute definitions read in as characters; convert to
    %numbers where appropriate
    theDefNum = str2num(theDef);
```

```
    if ~isempty(theDefNum)
        theDef = theDefNum;
        eval(['userMeta.',theAtt,' = theDef;'])
    else
        eval(['userMeta.',theAtt,'=''',theDef,''';'])
    end
end


% Gather instrument setup parameters
disp('Reading Argonaut setup parameters')
fid = fopen(ctlFile,'r');
while 1
    tline = fgetl(fid);
    %comments are tricy to read. assume they
    %use 3 lines for now
    if strcmp(tline,'Comments:')
        theDef=[fgetl(fid),'; ',fgetl(fid),'; ',fgetl(fid)];
        eval(['argnMeta.Comments =''',theDef,''';'])
        break
    end
    if ~isempty(tline) & ~strcmp(tline(1:8),'Argonaut') & ~strcmp(tline(1),'-
')
        theAtt = tline(1:28);
        theDef = tline(29:end);
        %if the parameter contains units in parenthesis, the
        %units will be written as theAtt.units = units
        fs = strfind(theAtt,'(');
        fe = strfind(theAtt,')');
        if ~isempty(fs) & ~isempty(fe)
            theUnits = theAtt(fs+1:fe-1);
            theAtt=regexprep(theAtt,'\([^)]*\)','');
        end
        %check for and remove dashes in
        %the parameters
        f = strfind(theAtt,'-');
        if ~isempty(f)
            theAtt(f) = [];
        end
        %check for and remove slashes in
        %the parameters
        f = strfind(theAtt,'/');
        if ~isempty(f)
            theAtt(f)= [];
        end
        %deblank removes trailing whitespace
        theAtt = deblank(theAtt);
        theDef = deblank(theDef);
        %replace whitespace with underscores in parameter
        %names
        f = isspace(theAtt);
        theAtt(f) = '_';
        %transformation matrix is tricky to read in
        if strcmp(theAtt,'Transformation_Matrix')
            temp = fscanf(fid,'%6f',[3,2]);
            temp = temp';
```

```
            temp = num2str(temp);
            theDef = strvcat(theDef, temp);
        end
        %parameter values read in as characters; convert to
        %numbers where appropriate
        theDefNum = str2num(theDef);
        if ~isempty(theDefNum) & isempty(strfind(theAtt,'Time'))
            %parameter value is numeric
            eval(['argnMeta.',theAtt,' = theDefNum;'])
        else
            %parameter value is ascii
            eval(['argnMeta.',theAtt,'=''',theDef,''';'])
        end
        if exist('theUnits')
            eval(['argnMeta.',theAtt,'Units=''',theUnits,''';'])
            clear theUnits
        end
    end
end
fclose(fid);

return
```

```
function nccreate_argnWvs(userMeta, argnMeta, outFileRoot)
% nccreate_argnWvs.m  A function to create empty netCDF files that will
%                     store wave data from a Sontek Argonaut.
%
%    usage:  nccreate_argnWvs(userMeta, argnMeta, outFileRoot);
%
%        where: userMeta - a structure with user-defined metadata
%               argnMeta - a structure with Argonaut setup parameters
%               outFileRoot -  a string specifying the name given to the
%                              NetCDF output files, in single quotes
%                              excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov

% C. Sullivan   03/30/06,   version 1.2
% Use EPIC keys 1239 and 4063 for the variables hght_std and wp_peak,
% respectively.
% C. Sullivan   11/02/05,   version 1.1
% Provide the user additional feedback regarding code execution. Changed
% DATA_TYPE attribute description to be consistent w/ the documentation.
% Changed EPIC code and units on the variable lon to 502 and degree_east
% for consistency w/ longitude as specified in the metadata file where west
% is negative.
% C. Sullivan   06/01/05,   version 1.0
% Instrument setup information is now included in the metadata.  Only the
% processed data NetCDF file is created; the file includes wave parameters
% which were calculated from a 1 Hz pressure timeseries.  No raw data
% NetCDF file is created as the 1 Hz pressure timeseries s not output by
% ViewArgonaut.  It is assumed there are 10 frequency bands in the wave
% energy spectra.


version = '1.2';

ncp = netcdf([outFileRoot,'p-cal.nc'],'clobber');

write_argnWvs_meta(ncp, userMeta, argnMeta)
ncp.DATA_TYPE = ncchar('Argonaut processed wave parameters and spectra');
ncp.VAR_DESC = ncchar('Hs:Tp:Pspec');

% Define NetCDF dimensions
disp(' ')
disp(['Defining NetCDF dimensions in ',outFileRoot,'p-cal.nc.'])
define_argnWvs_dims(ncp);

% Define NetCDF variables
disp(['Defining NetCDF variables in ',outFileRoot,'p-cal.nc.'])
disp(' ')
define_argnWvs_vars(ncp);

endef(ncp);
ncp=close(ncp);
```

```
return

% --------- Subfunction: Write NetCDF metadata ------------------------- %
function write_argnWvs_meta(nc, userMeta, argnMeta)

    theAtts = fieldnames(userMeta);

    for a=1:length(theAtts)
        eval(['theDef = userMeta.',theAtts{a},';'])
        if ischar(theDef)
            eval(['nc.',theAtts{a},' = ncchar('''',theDef,''');']);
        else
            eval(['nc.',theAtts{a},' = ncfloat([theDef]);']);
        end
    end

    theAtts = fieldnames(argnMeta);

    for a=1:length(theAtts)
        eval(['theDef = argnMeta.',theAtts{a},';'])
        if ischar(theDef)
            eval(['nc.',theAtts{a},' = ncchar('''',theDef,''');']);
        else
            eval(['nc.',theAtts{a},' = ncfloat([theDef]);']);
        end
    end

return

% --------- Subfunction: Define NetCDF dimensions ---------------------- %
function define_argnWvs_dims(nc)

    nc('time') = 0;
    nc('lat') = 1;
    nc('lon') = 1;
    nc('frequency') = 10; % it is assumed there are 10 frequency bands

return

% --------- Subfunction: Define NetCDF variables ----------------------- %
function define_argnWvs_vars(nc)

    %coordinate variables
    nc{'burst'} = nclong('time');
    nc{'burst'}.FORTRAN_format = ncchar('F10.2');
    nc{'burst'}.units = ncchar('counts');
    nc{'burst'}.type = ncchar('EVEN');

    nc{'lat'} = ncfloat('lat');
    nc{'lat'}.FORTRAN_format = ncchar('F10.4');
    nc{'lat'}.units = ncchar('degree_north');
    nc{'lat'}.type = ncchar('EVEN');
    nc{'lat'}.epic_code = nclong(500);

    nc{'lon'} = ncfloat('lon');
```

```
    nc{'lon'}.FORTRAN_format = ncchar('F10.4');
    nc{'lon'}.units = ncchar('degree_east');
    nc{'lon'}.type = ncchar('EVEN');
    nc{'lon'}.epic_code = nclong(502);

    nc{'time'} = nclong('time');
    nc{'time'}.FORTRAN_format = ncchar('F10.2');
    nc{'time'}.units = ncchar('True Julian Day');
    nc{'time'}.type = ncchar('EVEN');
    nc{'time'}.epic_code = nclong(624);

    nc{'time2'} = nclong('time');
    nc{'time2'}.FORTRAN_format = ncchar('F10.2');
    nc{'time2'}.units = ncchar('msec since 0:00 GMT');
    nc{'time2'}.type = ncchar('EVEN');
    nc{'time2'}.epic_code = nclong(624);

    %record variables -- EPIC variables
    nc{'wh_4061'} = ncdouble('time','lat','lon');
    nc{'wh_4061'}.long_name=ncchar('Significant Wave Height (m)');
    nc{'wh_4061'}.generic_name=ncchar('Hs');
    nc{'wh_4061'}.units=ncchar('m');
    nc{'wh_4061'}.epic_code=nclong(4061);
    nc{'wh_4061'}.FORTRAN_format=ncchar('F10.2');
    nc{'wh_4061'}.FillValue_ = 1.0000000409184788E35;
    nc{'wh_4061'}.minimum = ncfloat(0);
    nc{'wh_4061'}.maximum = ncfloat(0);

    nc{'hght_18'} = ncdouble('time','lat','lon');
    nc{'hght_18'}.long_name=ncchar('Height of the Sea Surface (m)');
    nc{'hght_18'}.generic_name=ncchar('height');
    nc{'hght_18'}.units=ncchar('m');
    nc{'hght_18'}.epic_code=nclong(18);
    nc{'hght_18'}.FORTRAN_format=ncchar('F10.2');
    nc{'hght_18'}.NOTE=ncchar('height of sea surface relative to sensor');
    nc{'hght_18'}.FillValue_ = 1.0000000409184788E35;
    nc{'hght_18'}.minimum = ncfloat(0);
    nc{'hght_18'}.maximum = ncfloat(0);

    %record variables -- non-EPIC variables
    nc{'hght_std'} = ncdouble('time','lat','lon');
    nc{'hght_std'}.long_name=ncchar('Standard Deviation of Height of the Sea
Surface (m)');
    nc{'hght_std'}.generic_name=ncchar('height std');
    nc{'hght_std'}.units=ncchar('m');
    nc{'hght_std'}.epic_code=nclong(1239);
    nc{'hght_std'}.FORTRAN_format=ncchar('F10.2');
    nc{'hght_std'}.FillValue_ = 1.0000000409184788E35;
    nc{'hght_std'}.minimum = ncfloat(0);
    nc{'hght_std'}.maximum = ncfloat(0);

    nc{'frequency'}=ncdouble('frequency');
    nc{'frequency'}.name=ncchar('freq');
    nc{'frequency'}.long_name=ncchar('Frequency (Hz)');
    nc{'frequency'}.generic_name=ncchar('frequency');
    nc{'frequency'}.units=ncchar('Hz');
```

```
    nc{'frequency'}.NOTE=ncchar('frequency at the center of each frequency
band');
    nc{'frequency'}.FORTRAN_format=ncchar('F10.2');
    nc{'frequency'}.minimum = ncfloat(0);
    nc{'frequency'}.maximum = ncfloat(0);

    nc{'wp_peak'} = ncdouble('time','lat','lon');
    nc{'wp_peak'}.long_name=ncchar('Peak Wave Period (s)');
    nc{'wp_peak'}.generic_name=ncchar('Tp');
    nc{'wp_peak'}.units=ncchar('s');
    nc{'wp_peak'}.epic_code=nclong(4063);
    nc{'wp_peak'}.FORTRAN_format=ncchar('F10.2');
    nc{'wp_peak'}.FillValue_ = 1.0000000409184788E35;
    nc{'wp_peak'}.minimum = ncfloat(0);
    nc{'wp_peak'}.maximum = ncfloat(0);

    nc{'pspec'}=ncfloat('time','frequency','lat','lon');
    nc{'pspec'}.name=ncchar('pspec');
    nc{'pspec'}.long_name=ncchar('Pressure-derived Non-directional Wave
Height Spectrum (mm/sqrt(Hz))');
    nc{'pspec'}.generic_name=ncchar('velocity spectrum');
    nc{'pspec'}.units=ncchar('mm/sqrt(Hz)');
    nc{'pspec'}.FORTRAN_format=ncchar('F10.2');
    nc{'pspec'}.FillValue_ = 1.0000000409184788E35;
    nc{'pspec'}.minimum = ncfloat(0);
    nc{'pspec'}.maximum = ncfloat(0);

return
```

```
function [argnData]=read_argnWvs(datFile)
% read_aqdpWvs.m  A function to read wave data from a Sontek Argonaut.
%
%   usage:  [argnData]=read_argnWvs;
%
%       where:  argnData - a structure with the following fields
%                   datFile - name of the .dat file to which ViewArgonaut
%                             output data
%                   burst   - burst number
%                   YYYY    - 4-digit year
%                   MM      - month
%                   DD      - day
%                   hh      - hours
%                   mm      - minutes
%                   ss      - seconds
%                   Hs      - significant wave height, cm
%                   Tp      - peak wave period, s
%                   ht      - water depth from pressure sensor, dBar
%                   ht_std  - standard deviation water depth, dBar
%                   amp     - wave amplitude, mm
%
% Written by Charlene Sullivan
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% Woods Hole, MA 02543
% csullivan@usgs.gov

% C. Sullivan   11/02/05,   version 1.1
% Provide user additional feedback regarding code execution.
% C. Sullivan   06/01/05,   version 1.0
% Output the data in a structure.  The data output in the structure will be
% in the same units as it is in the .dat file.  All unit conversions and
% calculation of the wave energy spectra will take place when the data is
% written to NetCDF.


version = '1.1';

argnData.datFile = datFile;

disp(['Reading statistical wave parameters from ',argnData.datFile])

% Load the data
data = load(argnData.datFile);
argnData.burst = [1:size(data,1)]';
argnData.YYYY = data(:,1);
argnData.MM = data(:,2);
argnData.DD = data(:,3);
argnData.hh = data(:,4);
argnData.mm = data(:,5);
argnData.ss = data(:,6);
argnData.Hs = data(:,47);
argnData.Tp = data(:,48);
argnData.ht = data(:,30);
argnData.ht_std = data(:,31);
argnData.amp = data(:,37:46);
```

```
return
```

```
function ncwrite_argnWvs(argnData, outFileRoot)
% ncwrite_adcpWvs.m  A function to write wave data from a Sontek Argonaut.
%
%   usage:  ncwrite_aqdpWvs(argnData, outFileRoot);
%       where:  argnData - a structure with the following fields
%                   datFile - name of the .dat file to which ViewArgonaut
%                             output data
%                   burst   - burst number
%                   YYYY    - 4-digit year
%                   MM      - month
%                   DD      - day
%                   hh      - hours
%                   mm      - minutes
%                   ss      - seconds
%                   Hs      - significant wave height, cm
%                   Tp      - peak wave period, s
%                   ht      - water depth from pressure sensor, dBar
%                   ht_std  - standard deviation water depth, dBar
%                   amp     - wave amplitude, mm
%               outFileRoot - a string specifying the name given to the
%                             NetCDF output files, in single quotes
%                             excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Dependencies:
%   julian.m
%   gregorian.m
%   gmin.m
%   gmax.m

% C.Sullivan    03/30/06,   version 1.3
% Reverse the chronology on the history attribute so the most recent
% processing step is listed first.  For max and min attributes on the
% variable pspec, calculate the maxs and mins over time for each frequency
% band.
% C.Sullivan    11/02/05,   version 1.2
% Provide the user additional feedback regarding code execution.
% C. Sullivan   06/09/05,   version 1.1
% Users is interactively asked to view a plot to determine which bursts are
% good.  Only good bursts are written to NetCDF.
% C. Sullivan   06/01/05,   version 1.0
% Unit conversions and the calculation of wave spectra take place in this
% m-file.  Data is written to the processed data NetCDF file.  No raw data
% NetCDF file is produced as the 1 Hz pressure timeseries from which wave
% parameters are calculated is not output by ViewArgonaut.


version = '1.2';

% ---- Define good data to write to NetCDF ----------------------------- %
%display a figure with two subplots.  the first subplot has mean pressure
%and the standard deviation of pressure.  the second subplot contains the
```

```
%significant wave height, and the peak wave period.  the user is asked to
%view these plots (zooming in and out) and determine the first and last
%good bursts of data.  all data between the first and last
%good data points will be written to NetCDF.
F=figure;
set(F,'position',[200 100 800 800])
subplot(411)
plot(argnData.burst, argnData.ht)
ylabel({'Pressure','(dBar)'})
subplot(412)
plot(argnData.burst, argnData.ht_std)
ylabel({'Pressure Standard','Deviation (dBar)'})
subplot(413)
plot(argnData.burst, argnData.Hs)
ylabel({'Significant','Wave Height (cm)'})
subplot(414)
plot(argnData.burst, argnData.Tp)
ylabel({'Peak Wave','Period (s)'})
xlabel('Index')

disp(' ')
disp('Please view the figure (feel free to zoom!) and look for indices which
might be bad')
disp('Bad indices might include out-of-water indices, for example')
answer = input(['Would you like to write all indices (indices 1:',...
              num2str(length(argnData.burst)),') to NetCDF? y/n :  '],'s');
if ~strcmp(answer,'Y') & ~strcmp(answer,'y') & ...
   ~strcmp(answer,'N') & ~strcmp(answer,'n')
        disp(['Valid answers are either yes ("y") or no ("n")'])
        answer = input(['Would you like to write all indices (indices 1:',...
                        num2str(length(argnData.burst)),') to NetCDF? y/n :
'],'s');
end
if strcmp(answer,'Y') || strcmp(answer,'y')
    first_good = 1;
    last_good = length(argnData.burst);
    disp(['Including indices 1 through ',num2str(length(argnData.burst)),' in
PUV analysis'])
elseif strcmp(answer,'N') || strcmp(answer,'n')
    first_good = input('Please view the figure and enter the first good
indice:  ');
    if isempty(first_good)
        disp('Valid answers are numeric only')
        first_good = input('Please view the figure and enter the first good
indice:  ');
    end
    last_good = input('Please view the figure and enter the last good indice:
');
    if isempty(last_good)
        disp('Valid answers are numeric only')
        last_good = input('Please view the figure and enter the last good
indice:  ');
    end
    disp(['Writing indices ',num2str(first_good),' to ',num2str(last_good),
...
          ' to NetCDF'])
```

```
end
goodBursts = [first_good:last_good];
nGoodBursts = length(goodBursts);

theVars = fieldnames(argnData);
for v = 1:length(theVars)
    if ~strcmp(theVars{v},'datFile')
        if strcmp(theVars{v},'amp')
            argnData.amp = argnData.amp(goodBursts,:);
        else
            eval(['argnData.',theVars{v},' =
argnData.',theVars{v},'(goodBursts);'])
        end
    end
end

% ---- Calculate wave energy density ------------------------------------ %
%convert 'amplitude at 10 period bands' into energy density in mm/sqrt(Hz)
%according to P. Work's equations.
%wave period bands are 2 seconds wide.  the first band begins at 2 seconds.
%the last bin is for periods > 20 seconds.
T_low = [2:2:20]';
T_high = [4:2:22]';
T_high(end) = 22; %  <--- ??? larger period defining the last bin
dF = 1./T_low - 1./T_high;

totEnergy = 0.5 .* sum((argnData.amp.^2)); %total energy in each band
Hmo = 4 .* sqrt(totEnergy); % zero-moment wave height in each band

for i=1:length(dF)
    E(:,i) = (0.5*(argnData.amp(:,i).^2)) ./ dF(i); %energy density
                                                    %(cm^2/Hz) in each band
end

argnData.pspec = sqrt(E).*10; %we call pressure-derived energy density
                              %'pspec' and the units we like are mm/sqrt(Hz)

argnData.frequency = 1./T_low + dF/2; %we also like to have the frequency
                                      %at the center of each frequency band

% ---- Write data to to NetCDF ------------------------------------ %

disp(' ')
disp(['Writing statistical wave parameters and spectra to ',outFileRoot,'p-
cal.nc'])

nc=netcdf([outFileRoot,'p-cal.nc'],'write');

% Convert time from gregorian to julian and get
% start_time and stop_time
time = julian([argnData.YYYY, argnData.MM, argnData.DD,...
               argnData.hh, argnData.mm, argnData.ss]);
start_time=datenum([gregorian(time(1))]);
stop_time=datenum([gregorian(time(end))]);

% Convert Hs from cm to m
```

```
argnData.Hs = argnData.Hs ./ 100;

% Get the number of records
nRec=length(time);

% Get the number of frequencies
theFreqDim = nc('frequency');
nFreq = size(theFreqDim);
nFreq = nFreq(1);

% Write data to netCDF file
% write coordinate variables
nc{'time'}(1:nRec) = floor(time);
nc{'time2'}(1:nRec) = (time-floor(time)).*(24*3600*1000);
nc{'burst'}(1:nRec) = argnData.burst;
nc{'lat'}(1)=nc.latitude(:);
nc{'lon'}(1)=nc.longitude(:);

% write record variables
ncvarnames = {'wh_4061','wp_peak','hght_18','hght_std','frequency','pspec'};
names = {'Hs','Tp','ht','ht_std','frequency','pspec'};
nNames = length(names);
for i = 1:nNames
    eval(['data = argnData.',names{i},';'])
    eval(['nco = nc{''',ncvarnames{i},'''};'])
    nco.maximum = gmax(data);
    nco.minimum = gmin(data);
    theFillVal = nco.FillValue_(:);
    bads = find(isnan(data));
    data(bads) = theFillVal;
    if strcmp(ncvarnames(i),'pspec')
        nco(1:nRec, 1:nFreq) = data;
    elseif strcmp(ncvarnames(i),'frequency')
        nco(1:nFreq) = data;
    else
        nco(1:nRec) = data;
    end
    disp(['Finished writing ',nco.long_name(:)])
end

% Add the following netcdf file attributes
nc.CREATION_DATE = ncchar(datestr(now,0));
nc.start_time = ncchar(datestr(start_time,0));
nc.stop_time = ncchar(datestr(stop_time,0));

% Update the history attribute
history = nc.history(:);
history_new = ['Wave energy spectra calculated and data converted ',...
               'to NetCDF by argnWvs2nc:ncwrite_argnWvs.m V ',version,...
               ' on ' datestr(now,0),'; ',history];
nc.history = history_new;

% Close netCDF file
nc=close(nc);

elapsed_time = toc;
```

```
disp(['Finished writing statistical wave parameters and spectra. ',...
      num2str(toc/60),' minutes elapsed.'])

return
```

Appendix VI: M-files for Nortek AP

```
function aqdpWvs2nc(metaFile,outFileRoot);
% aqdpWvs2nc.m  A driver M-file for post-processing Nortek Aquadopp wave
%               data.
%
%    usage:  adcpWvs2nc(metaFile,outFileRoot);
%
%        where:  metaFile    - a string specifying the ascii file in which
%                              metadata is defined, in single quotes
%                              excluding the .txt file extension
%                outFileRoot - a string specifying the name given to the
%                              NetCDF output files, in single quotes
%                              excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Toolbox Functions:
%   get_meta_nortek.m
%   wad2puv.m
%   nccreate_aqdpWvs.m
%   ncwrite_aqdpWvs.m
%   ncwrite_aqdpWvs_raw.m
%
% Add-on Functions:
%   beam2enu.m
%   wds.m
%   hs.m
%   julian.m
%   gmean.m
%   gmin.m
%   gmax.m

% C. Sullivan   10/27/05,   version 1.2
% Remove isunix loop b/c dir works on both unix and windows. Provide user
% additional feedback regarding code execution.  Metadata file must be a
% .txt file.  Don't require the .txt file extension in the input 'metaFile'.
% C. Sullivan   06/07/05,   version 1.1
% I also need the name of the .whd file output from AquaPro.  This file
% has heading, pitch, and roll information used to convert velocities
% from BEAM to ENU coordinates for PUV analysis.
% C. Sullivan   06/02/05,   version 1.0
% This Aquadopp component of the Wave Data Processing System toolbox writes
% both processed data and raw data NetCDF files. All user-defined metadata
% and instrument information is included in these files. The raw data
% NetCDF file contains the raw pressures and velocities used in the PUV
% analysis. User interaction is required to define which raw pressures and
% velocities are good (ie: in the water).  These good pressures and
% velocities are transformed from beam to geographic coordinates (if
% necessary) and then run through PUV analysis.  The results are written to
```

```
% the processed data NetCDF file.  Therefore, out-of-water data is excluded
% from PUV analysis and the processed data NetCDF file.


version = '1.2';

more off

tic

% Check inputs
if ~ischar(metaFile) || ~ischar(outFileRoot)
    error('File names should be surrounded in single quotes');
end

% Check existence of metadata file and Aquapro v. 1.25 output
l = dir([metaFile,'.txt']);
if isempty(l)
    error(['The metafile ',metaFile,'.txt does not exist in this
directory']);
end

wad = dir('*.wad');
whd = dir('*.whd');
hdr = dir('*.hdr');
if isempty(wad) || isempty(whd) || isempty(hdr)
    error(['AquaPro output files do not exist in this directory'])
elseif length(wad) > 1 length(whd) > 1 || length(hdr) > 1
    error(['Too many .wad or .hdr files exist in this directory'])
else
    wadFile = wad.name;
    whdFile = whd.name;
    hdrFile = hdr.name;
end

% Gather user-defined and instrument metadata
[userMeta, aqdpMeta] = get_meta_nortek(metaFile, hdrFile);

% Perform PUV analysis
[burstData, puvData, aqdpMeta] = wad2puv(wadFile, whdFile, aqdpMeta,
userMeta);

% Create and define your netcdf files
nccreate_aqdpWvs(userMeta, aqdpMeta, outFileRoot);

% Write data from puv analysis to processed data netcdf file
ncwrite_aqdpWvs(puvData, outFileRoot);

% Write raw pressures and velocities to raw data netcdf file
ncwrite_aqdpWvs_raw(burstData, outFileRoot);
```

```
function [userMeta, aqdpMeta] = get_meta_nortek(metaFile, hdrFile);
% get_meta_nortek.m  A function to load user-defined metadata and
%                    instrument setup parameters for a Nortek Aquadopp
%                    Profiler (AP).
%
%   usage:  [userMeta, aqdpMeta] = get_meta_nortek(metaFile, hdrFile);
%
%       where:  metaFile - a string specifying the ascii file in which
%                          metadata is defined, in single quotes
%                          excluding the .txt file extension
%               hdrFile - a string specifying the ascii file in which
%                         Aquadopp setup parameters are defined, in single
%                         quotes including the extension .hdr
%               userMeta - a structure with user-defined metadata
%               aqdpMeta - a structure with Aquadopp setup parameters
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov

% C. Sullivan   10/27/05,   version 1.1
% Metadata file must be a .txt file.  The .txt extension is not required in
% the input 'metaFile'. Provide the user additional feedback regarding code
% execution.
% C. Sullivan   06/02/05,   version 1.0
% This function is coded to read a user-defined metadata file with specific
% formatting.  See the toolbox documentation for more information.


version = '1.1';

% Gather user-defined metadata
disp(' ')
disp('Reading user metadata')
[atts, defs] = textread([metaFile,'.txt'],'%s %63c','commentstyle','shell');
defs = cellstr(defs);
for i = 1:length(atts)
    theAtt = atts{i}(:)';
    theDef = defs{i}(:)';
    %deblank removes trailing whitespace
    theAtt = deblank(theAtt);
    theDef = deblank(theDef);
    %check for and replace spaces in
    %the attributes with underscores
    f1 = find(isspace(theAtt));
    f2 = strfind(theAtt,'-');
    f = union(f1,f2);
    if ~isempty(f)
        theAtt(f) = '_';
    end
    %attribute definitions read in as characters; convert to
    %numbers where appropriate
    theDefNum = str2num(theDef);
    if ~isempty(theDefNum)
        theDef = theDefNum;
```

```
        eval(['userMeta.',theAtt,' = theDef;'])
    else
        eval(['userMeta.',theAtt,'=''',theDef,''';'])
    end
end


% Gather instrument setup parameters
disp('Reading Aquadopp setup parameters')
fid = fopen(hdrFile,'r');
while 1
    tline = fgetl(fid);
    if ~isempty(tline) & ~strcmp(tline(1),'[') & ~strcmp(tline(1),'-') & ...
       ~strcmp(tline,'User setup') & ~strcmp(tline,'Hardware configuration')
& ...
       ~strcmp(tline,'Head configuration') & ~strcmp(tline,'Data file
format')
        %deblank removes trailing whitespace
        theAtt = deblank(tline(1:38));
        theDef = deblank(tline(39:end));
        %check for and replace spaces in
        %the parameters with underscores
        f = find(isspace(theAtt));
        if ~isempty(f)
            theAtt(f) = '_';
        end
        %check for and replace dashes in
        %the parameters with underscores
        f = strfind(theAtt,'-');
        if ~isempty(f)
            theAtt(f) = [];
        end
        %parameter values read in as characters; convert to
        %numbers where appropriate
        theDefNum = str2num(theDef);
        if ~isempty(theDefNum) & ~strcmp(theAtt(1:4),'Time')
            theDef = theDefNum;
            eval(['aqdpMeta.',theAtt,' = theDef;'])
        else
            eval(['aqdpMeta.',theAtt,'=''',theDef,''';'])
        end
    end
    %only read up to data file format in the .hdr file
    if strcmp(tline,'Head configuration'), break, end
end
fclose(fid);

return
```

```
function [burstData, puvData, aqdpMeta] = wad2puv(wadFile, whdFile, aqdpMeta,
userMeta);
% wad2puv.m  A function to run PUV analysis on wave data from a Nortek
%            Aquadopp.
%
%   usage:  [burstData, puvData] = wad2puv(wadFile, aqdpMeta, userMeta);
%
%       where:  burstData - a structure with the following fields
%                       burst - a vector of burst numbers
%                          dn - time, ML datenum
%                           p - pressure, m
%                           u - east velocity, m/s
%                           v - north velocity, m/s
%                           w - vertical velocity, m/s
%                           a - amplitude, counts
%               puvData - a structure with the following fields
%                            burst - a vector of burst numbers
%                               dn - time, ML datenum
%                                p - burst-mean pressure, m
%                             hsig - significant wave height, m
%                            peakF - wave frequency at the peak, Hz
%                           peakDir - wave direction at the peak, deg
%                         peakSpread - wave spreading at the peak, deg
%                                Su - surface elevation spectra based on
%                                     velocity, m^2/Hz
%                                Sp - surface elevation spectra based on
%                                     pressure, m^2/Hz
%                               Dir - wave direction, deg
%                            Spread - wave spreading
%                                 F - center frequency of each frequency
%                                     band
%                               dF - bandwidth of each frequency band
%                wadFile - the name of the .wad file output by AquaPro
%                whdFile - the name of the .whd file output by AquaPro
%               aqdpMeta - a structure containing Aquadopp setup
%                          parameters
%               userMeta - a structure containing user-defined metadata
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Dependencies:
%   beam2enu.m
%   gmean.m
%   wds.m
%   hs.m

% C. Sullivan   10/27/05,   version 1.2
% Provide user additional feedback regarding code execution.  Add version
% number.
% C. Sullivan   06/06/05,   version 1.1
% Velocities collected in beam coordinates must be converted to geographic
% coordinates prior to PUV analysis. Alert user that PUV parameters in
% user-defined metadata file are being applied. If user enters an erroneous
```

```
% input (anything non-numeric including carriage return) for either
% 'first_good' or 'last_good', they are now asked to re-enter their answers.
% C. Sullivan   06/02/05,   version 1.0
% This function combines elements of George Voulgaris' function split_wad.m
% and puv_nortek.m. The idea is to read the Aquadopp's .wad file, split the
% pressure and velocity data into individual bursts, and perform PUV
% analysis burst by burst for only good bursts. It is assumed colums 8, 9,
% and 17 in the .wad file are empty. The pressure and velocity data is
% stored in arrays that are dimensioned [nSamples x nBursts]. The user is
% asked which bursts to perform the PUV analysis on. The mfiles for the PUV
% analysis are wds.m and hs.m, which were provided by Nortek. The data from
% PUV analysis is stored in arrays that are dimensioned [1 x nGoodBursts]
% for wave parameters and [nFreq x nGoodBursts] for wave spectra.


version = '1.2';

disp(' ')

% ---- User and istrument metadata ------------------------------------- %
nSamples = aqdpMeta.Wave__Number_of_samples;                 %number of
samples
nums = ~isletter(aqdpMeta.Wave__Sampling_rate);
sampleDt = 1 / str2num(aqdpMeta.Wave__Sampling_rate(nums)); %sampling rate,
sec
nums = ~isletter(aqdpMeta.Wave__Interval);
burstDt = str2num(aqdpMeta.Wave__Interval(nums));           %wave interval,
sec
nums = ~isletter(aqdpMeta.Wave__Cell_size);
cell_ht = str2num(aqdpMeta.Wave__Cell_size(nums));          %height of
velocity
                                                            % cell above bed,
m
xducer_ht = userMeta.sensor_height;                         %height of sensor
                                                            % head above
                                                            % bed, m
coord_sys = aqdpMeta.Coordinate_system;                     %coordinate
system
                                                            % of data
MagDev = userMeta.magnetic_variation*pi/180;                %magnetic
variation,
                                                            % radians

% ---- PUV parameters -------------------------------------------------- %
lf = userMeta.lf; %low frequency cutoff, Hz
maxfac = userMeta.maxfac; %maximum value of factor scaling pressure to waves
minspec = userMeta.minspec; %minimum spectral level for computing direction
and spreading, mm^2/Hz
Ndir = userMeta.Ndir; %direction offset, deg (includes compass error and
misalignment of cable probe relative to case. (the offset for the Aquadopp
Profiler is 0)
nf = userMeta.nf; %nominal number of output frequencies

parms=[lf maxfac minspec Ndir];

% ---- Load data ------------------------------------------------------- %
```

```
disp(['Loading Aquadopp pressure and velocity data from ',wadFile,...
      '. This may take a few minutes.'])
data = load(wadFile);
mo = data(:,1);
day = data(:,2);
yy = data(:,3);
hh = data(:,4);
mi = data(:,5);
ss = data(:,6);
p = data(:,7);   % meters
v1 = data(:,10);  % beam1|X|East velocity (m/s)
v2 = data(:,11);  % beam2|Y|North velocity (m/s)
v3 = data(:,12);  % beam3|Z|UP velocity (m/s)
a1 = data(:,14); %Amplitude Beam 1  (counts)
a2 = data(:,15); %Amplitude Beam 2  (counts)
a3 = data(:,16); %Amplitude Beam 3  (counts)

data = load(whdFile);
hdg = data(:,12);
ptch = data(:,13);
roll = data(:,14);

% ---------------- Define time ----------------------------------------- %
%we use a time-based method for defining bursts in case the # of bursts
%recorded to the .wad file does not equal the length(.wad file)/nSamples
dnO = datenum(yy,mo,day,hh,mi,ss);  %time stamp on samples, ML datenum
dnOff = datenum(yy(1),1,1,0,0,0);
dn = dnO - dnOff;                   %<---  Why is this done?

clear nums data mo day yy hh mi ss

% ---------------- Split data ------------------------------------------ %
%with a time-based method for defining bursts, the time between
%bursts should be > (burstDt - (nSamples*sampleDt)). this is only valid
%when (nSamples*sampleDt) < burstDt
time_btw_bursts = (burstDt - (nSamples * sampleDt)) / (3600*24); %days

%Istart (a vector) indicates the indices in the .wad file
%at which bursts begin. however be sure to include 0 as the
%first value in Istart or else you will miss the first burst!
burst_start_ind = find(diff(dn) > time_btw_bursts); %<--- why not just use
dnO?
burst_start_ind = [0; burst_start_ind];

%number of bursts is equal to the length of burst_start_ind
nBursts = length(burst_start_ind);

%sometimes instrument is stopped during a burst
if length(dn) < (burst_start_ind(end)+nSamples)
    nBursts = nBursts-1;
end

%pre-allocate the structure burstData. pressure, velocities, amplitudes,
%and dates will be written to this structure as fields that are
%dimensioned [nSamples x nBursts]
burstData.burst = nan*ones(1, nBursts);
```

```
burstData.dn = nan*ones(nSamples, nBursts);
burstData.p = nan*ones(nSamples, nBursts);
burstData.u = nan*ones(nSamples, nBursts);
burstData.v = nan*ones(nSamples, nBursts);
burstData.w = nan*ones(nSamples, nBursts);
burstData.a = nan*ones(nSamples, nBursts);

%loop through the bursts and assign all samples in each burst to
%burstData
for b=1:nBursts;
  range = [ burst_start_ind(b)+1 : burst_start_ind(b)+nSamples ];
  burstData.burst(1,b) = b;
  burstData.dn(:,b) = dnO(range);
  burstData.p(:,b) = p(range);

  vv1 = v1(range); %all velocity samples in burst b
  vv2 = v2(range);
  vv3 = v3(range);

  switch coord_sys
      case 'BEAM'
          %if data was collected in BEAM coordinates, convert data to
          %geographic coordinates (and correct for magnetic variation).
          %do the conversion for each burst, sample by sample
          if mod(b,10)==0
              disp(['Converting velocities in burst ',num2str(b),' from BEAM
to ',...
                    'ENU coordinates, and correcting for declination. ',...
                    num2str(toc/60),' minutes elapsed'])
          end
          for ii = 1:nSamples
              vbeam = [vv1(ii) vv2(ii) vv3(ii)];
              venu=beam2enu(vbeam,hdg(b),ptch(b),roll(b),0);
              East(ii) = venu(1); %East
              North(ii) = venu(2); %North
              Up(ii) = venu(3); %Up
          end

              %correct for magnetic variation
              East_mag =  East*cos(MagDev) + North*sin(MagDev);
              North_mag = -East*sin(MagDev) + North*cos(MagDev);
              Up_mag = Up;

              burstData.u(:,b) = East_mag';
              burstData.v(:,b) = North_mag';
              burstData.w(:,b) = Up_mag';
      otherwise
          burstData.u(:,b) = vv1; %East
          burstData.v(:,b) = vv2; %North
          burstData.w(:,b) = vv3; %Up

  end

    burstData.a(:,b) = a1(range)+a2(range)+a3(range);

end
```

```
%clear variables you no longer need
clear p v1 v2 v3 a1 a2 a3

% ---- Define good bursts to include in PUV analysis -------------------- %
%display a figure with burst-averaged pressure and velocities.  ask the
%user if, based on the figure, they would like to include all bursts in the
%PUV analysis.  if the answer is no, ask the user to enter the the first
%and last good bursts. all bursts between the first and last good bursts
%will be included in PUV analysis.
figure
subplot(211)
plot(burstData.burst, gmean(burstData.p))
ylabel('Burst-mean pressure (m)')
xlabel('Burst number')
subplot(212)
plot(burstData.burst, gmean(burstData.u))
hold on
plot(burstData.burst, gmean(burstData.v),'r')
plot(burstData.burst, gmean(burstData.w),'g')
ylabel('Burst-mean Velocity (m/s)')
xlabel('Burst number')
legend('Eastward Velocity','Northward Velocity','Vertical Velocity')
disp(' ')
disp('Please view the figure (feel free to zoom!) and look for bursts which
might be bad')
disp('Bad bursts might include out-of-water bursts, for example.')
answer = input(['Would you like to include all bursts (bursts 1:',...
             num2str(nBursts),') in PUV analysis? y/n :  '],'s');
if ~strcmp(answer,'Y') & ~strcmp(answer,'y') & ...
   ~strcmp(answer,'N') & ~strcmp(answer,'n')
        disp(['Valid answers are either yes ("y") or no ("n")'])
        answer = input(['Would you like to include all bursts (bursts 1:',...
             num2str(nBursts),') in PUV analysis? y/n :  '],'s');

end
if strcmp(answer,'Y') || strcmp(answer,'y')
    first_good = 1;
    last_good = nBursts;
    disp(['Including bursts 1 through ',num2str(nBursts),' in PUV analysis'])
elseif strcmp(answer,'N') || strcmp(answer,'n')
    first_good = input('Please view the figure and enter the first good
burst:  ');
    if isempty(first_good)
        disp('Valid answers are numeric only')
        first_good = input('Please view the figure and enter the first good
burst:  ');
    end
    last_good = input('Please view the figure and enter the last good burst:
');
    if isempty(last_good)
        disp('Valid answers are numeric only')
        last_good = input('Please view the figure and enter the last good
burst:  ');
    end
```

```
    disp(['Including bursts ',num2str(first_good),' to ',num2str(last_good),
...
          ' in PUV analysis'])
    disp(' ')
end
goodBursts = [first_good:last_good];
nGoodBursts = length(goodBursts);

% ---- Do PUV Analysis ----------------------------------------------- %
disp(' ')
disp(['Performing PUV analysis.  This may take a few minutes'])
disp(' ')
disp('Users should have specified PUV parameters that suit their ')
disp('project needs in their metadata file.')
disp(['PUV parameter values defined the metadata file include:'])
disp(['     lf = ',num2str(lf),' Hz'])
disp(['     maxfac = ',num2str(maxfac)])
disp(['     minspec = ',num2str(minspec),' mm^2/Hz'])
disp(['     Ndir = ',num2str(Ndir),' deg'])
disp(' ')
%pre-allocate the structure puvData. results from the PUV analysis will
%will be written to this structure as fields
puvData.burst = nan*ones(1, nGoodBursts);
puvData.dn = nan*ones(1, nGoodBursts);
puvData.p = nan*ones(1, nGoodBursts);
puvData.Hsig = nan*ones(1, nGoodBursts);
puvData.peakF = nan*ones(1, nGoodBursts);
puvData.peakDir = nan*ones(1, nGoodBursts);
puvData.peakSpread = nan*ones(1, nGoodBursts);
puvData.Su = nan*ones(nf, nGoodBursts); %<--- use nF but the # of output
freq.
                                    %     is not necessarily nF.
puvData.Sp = nan*ones(nf, nGoodBursts);
puvData.Dir = nan*ones(nf, nGoodBursts);
puvData.Spread = nan*ones(nf, nGoodBursts);
puvData.F = nan*ones(nf, nGoodBursts);
puvData.dF = nan*ones(nf, nGoodBursts);

for b=1:nGoodBursts;

   burst = goodBursts(b);
   if mod(b,10) == 0
       disp(['Finished PUV analysis on burst ',num2str(burst),'. ',...
             num2str(toc/60),' minutes elapsed'])
   end
   dn = gmean(burstData.dn(:,burst)); %set time to time at center of burst
   p = gmean(burstData.p(:,burst));

   [Su,Sp,Dir,Spread,F,dF] =
WDS(burstData.u(:,burst),burstData.v(:,burst),...

burstData.p(:,burst),sampleDt,nf,xducer_ht,...
                                  cell_ht,parms);

   [Hsig,peakF,peakDir,peakSpread] = HS(Su,Sp,Dir,Spread,F,dF);
```

```
    theVars = fieldnames(puvData);

    for v=1:length(theVars)
        eval(['[nf_out, col] = size(',theVars{v},');'])
        if nf_out == 1
            eval(['puvData.',theVars{v},'(1,b) = ',theVars{v},';'])
        else
            eval(['puvData.',theVars{v},'(1:nf_out,b) = ',theVars{v},';'])
            if b == nGoodBursts & nf_out < nf
                 %remove extra rows (frequencies) if the number of
                 %output frequencies is less than the nominal number
                 %of frequencies (nf)
                 eval(['puvData.',theVars{v},'(nf_out+1:end,:) = [];'])
                 %add nf_out to instrument metatdata.  this value will be
                 %used to dimension NetCDF variables
                 aqdpMeta.nf_out = nf_out;
            end
        end
    end

end

disp(['Finished PUV analysis. ',num2str(toc/60),' minutes elapsed'])

return
```

```
function nccreate_aqdpWvs(userMeta, aqdpMeta, outFileRoot)
% nccreate_aqdpWvs.m  A function to create empty netCDF files that will
%                     store Nortek Aquadopp wave data.
%
%    usage:  nccreate_aqdpWvs(userMeta, aqdpMeta, outFileRoot);
%
%        where: userMeta - a structure with user-defined metadata
%               aqdpMeta - a structure with Aquadopp setup parameters
%               outFileRoot - a string specifying the name given to the
%                             NetCDF output files, in single quotes
%                             excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov

% C. Sullivan   03/29/06,   version 1.3
% Add EPIC codes to the variables wp_peak and wvdir.
% C. Sullivan   10/28/05,   version 1.2
% Provide the user additional feedback regarding code execution. Changed
% DATA_TYPE attribute description to be consistent w/ the documentation.
% Changed EPIC code and units on the variable lon to 502 and degree_east
% for consistency w/ longitude as specified in the metadata file where west
% is negative.
% C. Sullivan   06/09/05,   version 1.1
% The variables 'pspec' and 'vspec' will now have units of mm/sqrt(Hz) for
% consistency with RDI and SonTek spectra. (the old units were m^2/Hz)
% C. Sullivan   06/02/05,   version 1.0
% PUV analysis now run as part of the toolbox. Instrument setup information
% is now included in the metadata.  Two NetCDF output files are created;
% one file has the raw pressure and velocity data that was used in PUV
% analysis; the other has the processed data from the PUV analysis.


version = '1.2';

ncr = netcdf([outFileRoot,'r-cal.nc'],'clobber');
ncp = netcdf([outFileRoot,'p-cal.nc'],'clobber');

write_aqdpWvs_meta(ncr, userMeta, aqdpMeta)
ncr.DATA_TYPE = ncchar('Aquadopp pressure and velocity timeseries');
ncr.VAR_DESC = ncchar('u:v:w:p');

write_aqdpWvs_meta(ncp,userMeta, aqdpMeta)
ncp.DATA_TYPE = ncchar('Aquadopp processed wave parameters and spectra');
ncp.VAR_DESC = ncchar('Hs:Tp:Dp:Pspec:Vspec');

% Define NetCDF dimensions
disp(' ')
disp(['Defining NetCDF dimensions in ',outFileRoot,'r-cal.nc and ',...
       outFileRoot,'p-cal.nc'])
define_aqdpWvs_dims(ncr);
define_aqdpWvs_dims(ncp);

% Define NetCDF variables
```

```
disp(['Defining NetCDF variables in ',outFileRoot,'r-cal.nc and ',...
       outFileRoot,'p-cal.nc'])
disp(' ')
define_aqdpWvs_vars(ncr);
define_aqdpWvs_vars(ncp);

endef(ncr);
ncr=close(ncr);
endef(ncp);
ncp=close(ncp);

return

% --------- Subfunction: Write NetCDF metadata -------------------------- %
function write_aqdpWvs_meta(nc, userMeta, aqdpMeta)

    theAtts = fieldnames(userMeta);

    for a=1:length(theAtts)
        eval(['theDef = userMeta.',theAtts{a},';'])
        if ischar(theDef)
            eval(['nc.',theAtts{a},' = ncchar('''',theDef,''');']);
        else
            eval(['nc.',theAtts{a},' = ncfloat([theDef]);']);
        end
    end

    theAtts = fieldnames(aqdpMeta);

    for a=1:length(theAtts)
        eval(['theDef = aqdpMeta.',theAtts{a},';'])
        if ischar(theDef)
            eval(['nc.',theAtts{a},' = ncchar('''',theDef,''');']);
        else
            eval(['nc.',theAtts{a},' = ncfloat([theDef]);']);
        end
    end

return

% --------- Subfunction: Define NetCDF dimensions ----------------------- %
function define_aqdpWvs_dims(nc)

    %common dimensions for both raw and processed NetCDF files
    nc('time') = 0;
    nc('lat') = 1;
    nc('lon') = 1;

    if strcmp(nc.DATA_TYPE(:),'Aquadopp processed wave parameters and
spectra')
        %dimensions specific to processed NetCDF file
        nc('frequency') = nc.nf_out(:); %this is a result from the PUV
analysis
    elseif strcmp(nc.DATA_TYPE(:),'Aquadopp pressure and velocity
timeseries')
        %dimensions specific to raw NetCDF file
```

```
        nc('sample') = nc.Wave__Number_of_samples(:);
    end

return

% --------- Subfunction: Define NetCDF variables ------------------------ %
function define_aqdpWvs_vars(nc)

    %coordinate variables are the same for both the raw and
    %processed NetCDF files
    nc{'burst'} = nclong('time');
    nc{'burst'}.FORTRAN_format = ncchar('F10.2');
    nc{'burst'}.units = ncchar('counts');
    nc{'burst'}.type = ncchar('EVEN');

    nc{'lat'} = ncfloat('lat');
    nc{'lat'}.FORTRAN_format = ncchar('F10.4');
    nc{'lat'}.units = ncchar('degree_north');
    nc{'lat'}.type = ncchar('EVEN');
    nc{'lat'}.epic_code = nclong(500);

    nc{'lon'} = ncfloat('lon');
    nc{'lon'}.FORTRAN_format = ncchar('F10.4');
    nc{'lon'}.units = ncchar('degree_east');
    nc{'lon'}.type = ncchar('EVEN');
    nc{'lon'}.epic_code = nclong(502);


    if strcmp(nc.DATA_TYPE(:),'Aquadopp processed wave parameters and
spectra')
        %Record variables for ONLY the processed data NetCDF file.
        %EPIC variables
        nc{'time'} = nclong('time');
        nc{'time'}.FORTRAN_format = ncchar('F10.2');
        nc{'time'}.units = ncchar('True Julian Day');
        nc{'time'}.type = ncchar('EVEN');
        nc{'time'}.epic_code = nclong(624);

        nc{'time2'} = nclong('time');
        nc{'time2'}.FORTRAN_format = ncchar('F10.2');
        nc{'time2'}.units = ncchar('msec since 0:00 GMT');
        nc{'time2'}.type = ncchar('EVEN');
        nc{'time2'}.epic_code = nclong(624);

        nc{'wh_4061'} = ncdouble('time','lat','lon');
        nc{'wh_4061'}.long_name=ncchar('Significant Wave Height (m)');
        nc{'wh_4061'}.generic_name=ncchar('Hs');
        nc{'wh_4061'}.units=ncchar('m');
        nc{'wh_4061'}.epic_code=nclong(4061);
        nc{'wh_4061'}.FORTRAN_format=ncchar('F10.2');
        nc{'wh_4061'}.FillValue_ = 1.0000000409184788E35;
        nc{'wh_4061'}.minimum = ncfloat(0);
        nc{'wh_4061'}.maximum = ncfloat(0);

        nc{'hght_18'} = ncdouble('time','lat','lon');
        nc{'hght_18'}.long_name=ncchar('Height of the Sea Surface (m)');
```

```
        nc{'hght_18'}.generic_name=ncchar('height');
        nc{'hght_18'}.units=ncchar('m');
        nc{'hght_18'}.epic_code=nclong(18);
        nc{'hght_18'}.FORTRAN_format=ncchar('F10.2');
        nc{'hght_18'}.NOTE=ncchar('height of sea surface relative to
sensor');
        nc{'hght_18'}.FillValue_ = 1.0000000409184788E35;
        nc{'hght_18'}.minimum = ncfloat(0);
        nc{'hght_18'}.maximum = ncfloat(0);

        %non-EPIC variables
        nc{'frequency'}=ncdouble('frequency');
        nc{'frequency'}.name=ncchar('freq');
        nc{'frequency'}.long_name=ncchar('Frequency (Hz)');
        nc{'frequency'}.generic_name=ncchar('frequency');
        nc{'frequency'}.units=ncchar('Hz');
        nc{'frequency'}.type=ncchar('EVEN');
        nc{'frequency'}.NOTE=ncchar('frequency at the center of each
frequency band');
        nc{'frequency'}.FORTRAN_format=ncchar('F10.2');
        nc{'frequency'}.minimum = ncfloat(0);
        nc{'frequency'}.maximum = ncfloat(0);

        nc{'dfreq'}=ncdouble('frequency');
        nc{'dfreq'}.name=ncchar('freq');
        nc{'dfreq'}.long_name=ncchar('Frequency Band Width (Hz)');
        nc{'dfreq'}.generic_name=ncchar('freq band width');
        nc{'dfreq'}.units=ncchar('Hz');
        nc{'dfreq'}.FORTRAN_format=ncchar('F10.2');
        nc{'dfreq'}.minimum = ncfloat(0);
        nc{'dfreq'}.maximum = ncfloat(0);
        nc{'dfreq'}.NOTE = ncchar('Bandwidth of each frequency band');

        nc{'wp_peak'} = ncdouble('time','lat','lon');
        nc{'wp_peak'}.long_name=ncchar('Peak Wave Period (s)');
        nc{'wp_peak'}.generic_name=ncchar('Tp');
        nc{'wp_peak'}.units=ncchar('s');
        nc{'wp_peak'}.epic_code=nclong(4063);
        nc{'wp_peak'}.FORTRAN_format=ncchar('F10.2');
        nc{'wp_peak'}.FillValue_ = 1.0000000409184788E35;
        nc{'wp_peak'}.minimum = ncfloat(0);
        nc{'wp_peak'}.maximum = ncfloat(0);

        nc{'wvdir'} = ncdouble('time','lat','lon');
        nc{'wvdir'}.long_name=ncchar('Peak Wave Direction (degrees true
North)');
        nc{'wvdir'}.generic_name=ncchar('Dp');
        nc{'wvdir'}.units=ncchar('degrees');
        nc{'wvdir'}.epic_code=nclong(4062);
        nc{'wvdir'}.FORTRAN_format=ncchar('F10.2');
        nc{'wvdir'}.NOTE=ncchar('Direction FROM which waves are
propagating');
        nc{'wvdir'}.FillValue_ = 1.0000000409184788E35;
        nc{'wvdir'}.minimum = ncfloat(0);
        nc{'wvdir'}.maximum = ncfloat(0);
```

```
        nc{'spread'} = ncdouble('time','lat','lon');
        nc{'spread'}.long_name=ncchar('Peak Spreading');
        nc{'spread'}.generic_name=ncchar('spreading');
        nc{'spread'}.units=ncchar('degrees');
        nc{'spread'}.FORTRAN_format=ncchar('F10.2');
        nc{'spread'}.FillValue_ = 1.0000000409184788E35;
        nc{'spread'}.minimum = ncfloat(0);
        nc{'spread'}.maximum = ncfloat(0);

        nc{'pspec'}=ncfloat('time','frequency','lat','lon');
        nc{'pspec'}.name=ncchar('pspec');
        nc{'pspec'}.long_name=ncchar('Pressure-derived Non-directional Wave
Height Spectrum (mm/sqrt(Hz))');
        nc{'pspec'}.generic_name=ncchar('pressure spectrum');
        nc{'pspec'}.units=ncchar('mm/sqrt(Hz)');
        nc{'pspec'}.FORTRAN_format=ncchar('F10.2');
        nc{'pspec'}.FillValue_ = 1.0000000409184788E35;
        nc{'pspec'}.minimum = ncfloat(0);
        nc{'pspec'}.maximum = ncfloat(0);

        nc{'vspec'}=ncfloat('time','frequency','lat','lon');
        nc{'vspec'}.name=ncchar('vspec');
        nc{'vspec'}.long_name=ncchar('Velocity-derived Non-directional Wave
Height Spectrum (mm/sqrt(Hz))');
        nc{'vspec'}.generic_name=ncchar('velocity spectrum');
        nc{'vspec'}.units=ncchar('mm/sqrt(Hz)');
        nc{'vspec'}.FORTRAN_format=ncchar('F10.2');
        nc{'vspec'}.FillValue_ = 1.0000000409184788E35;
        nc{'vspec'}.minimum = ncfloat(0);
        nc{'vspec'}.maximum = ncfloat(0);

    elseif strcmp(nc.DATA_TYPE(:),'Aquadopp pressure and velocity
timeseries')
        %Record variables for ONLY the raw data NetCDF file.  There are no
        %EPIC-compatible variables for these quantities.
        nc{'time'} = nclong('time','sample');
        nc{'time'}.FORTRAN_format = ncchar('F10.2');
        nc{'time'}.units = ncchar('True Julian Day');
        nc{'time'}.type = ncchar('EVEN');
        nc{'time'}.epic_code = nclong(624);

        nc{'time2'} = nclong('time','sample');
        nc{'time2'}.FORTRAN_format = ncchar('F10.2');
        nc{'time2'}.units = ncchar('msec since 0:00 GMT');
        nc{'time2'}.type = ncchar('EVEN');
        nc{'time2'}.epic_code = nclong(624);

        nc{'sample'} = nclong('sample');
        nc{'sample'}.FORTRAN_format = ncchar('F10.2');
        nc{'sample'}.units = ncchar('counts');
        nc{'sample'}.type = ncchar('EVEN');

        nc{'hght_18'} = ncdouble('time','sample','lat','lon');
        nc{'hght_18'}.long_name=ncchar('Height of the Sea Surface (m)');
        nc{'hght_18'}.generic_name=ncchar('height');
        nc{'hght_18'}.units=ncchar('m');
```

```
        nc{'hght_18'}.epic_code=nclong(18);
        nc{'hght_18'}.FORTRAN_format=ncchar('F10.2');
        nc{'hght_18'}.NOTE=ncchar('height of sea surface relative to
sensor');
        nc{'hght_18'}.FillValue_ = 1.0000000409184788E35;
        nc{'hght_18'}.minimum = ncfloat(0);
        nc{'hght_18'}.maximum = ncfloat(0);

        nc{'u_1205'}=ncfloat('time','sample','lat','lon');
        nc{'u_1205'}.name=ncchar('u');
        nc{'u_1205'}.long_name=ncchar('Eastward Velocity (cm/s)');
        nc{'u_1205'}.generic_name=ncchar('u');
        nc{'u_1205'}.units=ncchar('cm/s');
        nc{'u_1205'}.epic_code=nclong(1205);
        nc{'u_1205'}.FORTRAN_format=ncchar('');
        nc{'u_1205'}.FillValue_ = 1.0000000409184788E35;
        nc{'u_1205'}.minimum = ncfloat(0);
        nc{'u_1205'}.maximum = ncfloat(0);

        nc{'v_1206'}=ncfloat('time','sample','lat','lon');
        nc{'v_1206'}.name=ncchar('v');
        nc{'v_1206'}.long_name=ncchar('Northward Velocity (cm/s)');
        nc{'v_1206'}.generic_name=ncchar('v');
        nc{'v_1206'}.units=ncchar('cm/s');
        nc{'v_1206'}.epic_code=nclong(1206);
        nc{'v_1206'}.FORTRAN_format=ncchar('');
        nc{'v_1206'}.FillValue_ = 1.0000000409184788E35;
        nc{'v_1206'}.minimum = ncfloat(0);
        nc{'v_1206'}.maximum = ncfloat(0);

        nc{'w_1204'}=ncfloat('time','sample','lat','lon');
        nc{'w_1204'}.name=ncchar('w');
        nc{'w_1204'}.long_name=ncchar('Vertical Velocity (cm/s)');
        nc{'w_1204'}.generic_name=ncchar('w');
        nc{'w_1204'}.units=ncchar('cm/s');
        nc{'w_1204'}.epic_code=nclong(1204);
        nc{'w_1204'}.FORTRAN_format=ncchar('');
        nc{'w_1204'}.FillValue_ = 1.0000000409184788E35;
        nc{'w_1204'}.minimum = ncfloat(0);
        nc{'w_1204'}.maximum = ncfloat(0);

        nc{'amp'}=ncfloat('time','sample','lat','lon');
        nc{'amp'}.units=ncchar('counts');
        nc{'amp'}.long_name=ncchar('Beam amplitude');
        nc{'amp'}.FillValue_ = 1.0000000409184788E35;
    end

return
```

```
function ncwrite_aqdpWvs(puvData, outFileRoot)
% ncwrite_adcpWvs.m  A function to write Aquadopp wave data, generated by
%                    PUV analysis, to a netCDF file.
%
%   usage:  ncwrite_aqdpWvs(puvData, outFileRoot);
%       where:  puvData - a structure with the following fields
%                              burst - a vector of burst numbers
%                                 dn - time, ML datenum
%                                  p - burst-mean pressure, m
%                               hsig - significant wave height, m
%                              peakF - wave frequency at the peak, Hz
%                            peakDir - wave direction at the peak, deg
%                         peakSpread - wave spreading at the peak, deg
%                                 Su - surface elevation spectra based on
%                                      velocity, m^2/Hz
%                                 Sp - surface elevation spectra based on
%                                      pressure, m^2/Hz
%                                Dir - wave direction, deg
%                             Spread - wave spreading
%                                  F - center frequency of each frequency
%                                      band
%                                 dF - bandwidth of each frequency band
%               outFileRoot - a string specifying the name given to the
%                             NetCDF output files, in single quotes
%                             excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Dependencies:
%   julian.m
%   gmean.m
%   gmin.m
%   gmax.m

% C. Sullivan   03/29/06,   version 1.4
% Reverse the chronology on the history attribute so the most recent
% processing step is listed first.  For spectra variables, calculate min
% and max attributes over time for each frequency.
% C. Sullivan   10/28/05,   version 1.3
% ADCP wave direction is direction FROM!!  Wave direction from PUV analysis
% is direction TO, so convert it do direction FROM to be consistent with
% ADCP waves.
% C. Sullivan   06/13/05,   version 1.2
% Wave direction, 'wvdir', is output by PUV analysis as 'direction from'.
% Convert wave direction to 'direction to' for consistency with ADCP and
% Argonaut peak wave directions.
% C. Sullivan   06/09/05,   version 1.1
% The variables 'pspec' and 'vspec' are converted from m^2/Hz to
% mm/sqrt(Hz)
% C. Sullivan   06/02/05,   version 1.0
% This function writes the data from PUV analysis to the processed data
% NetCDF file.
```

```
version = '1.4';

disp(' ')
disp(['Writing statistical wave parameters to ',outFileRoot,'p-cal.nc'])

nc=netcdf([outFileRoot,'p-cal.nc'],'write');

% Convert time from datenum to julian and get
% start_time, stop_time
time_greg = datevec(puvData.dn);
time = julian([time_greg]);
start_time=puvData.dn(1);
stop_time=puvData.dn(end);

% Convert peak wave direction from 'direction to' to 'direction from'
f=find(puvData.peakDir<0);
puvData.peakDir(f)=360+puvData.peakDir(f);
puvData.peakDir(f)=puvData.peakDir(f)-180;

% Convert spectra from m^2/Hz to mm/sqrt(Hz)
puvData.Su = sqrt(puvData.Su') .* 1000;
puvData.Sp = sqrt(puvData.Sp') .* 1000;

% Convert frequency to period
puvData.peakF = 1 ./ puvData.peakF;

% 'frequency' and 'dfreq' are the same for each burst, so just use the
% burst-mean.
puvData.F = gmean(puvData.F');
puvData.dF = gmean(puvData.dF');

% Get the number of records
nRec=length(time);

% Get the number of frequencies
theFreqDim = nc('frequency');
nFreq = size(theFreqDim);
nFreq = nFreq(1);

% Write data to netCDF file
% write coordinate variables
nc{'time'}(1:nRec) = floor(time);
nc{'time2'}(1:nRec) = (time-floor(time)).*(24*3600*1000);
nc{'burst'}(1:nRec) = puvData.burst;
nc{'lat'}(1)=nc.latitude(:);
nc{'lon'}(1)=nc.longitude(:);

% write record variables
ncvarnames = {'wh_4061','wp_peak','wvdir','spread','hght_18','vspec',...
              'pspec','frequency','dfreq'};
names = {'Hsig','peakF','peakDir','peakSpread','p','Su','Sp','F','dF'};
nNames = length(names);
for i = 1:nNames
    eval(['data = puvData.',names{i},';'])
    eval(['nco = nc{''',ncvarnames{i},'''};'])
```

```
    nco.maximum = gmax(data);
    nco.minimum = gmin(data);
    theFillVal = nco.FillValue_(:);
    bads = find(isnan(data));
    data(bads) = theFillVal;
    if strcmp(ncvarnames(i),'vspec') || strcmp(ncvarnames(i),'pspec')
        nco(1:nRec, 1:nFreq) = data;
    elseif strcmp(ncvarnames(i),'frequency') || strcmp(ncvarnames(i),'dfreq')
        nco(1:nFreq) = data;
    else
        nco(1:nRec) = data;
    end
    disp(['Finished writing ',nco.long_name(:)])
end

% Add the following netcdf file attributes
nc.CREATION_DATE = ncchar(datestr(now,0));
nc.start_time = ncchar(datestr(start_time,0));
nc.stop_time = ncchar(datestr(stop_time,0));

% Update the history attribute
history = nc.history(:);
history_new = ['Data converted to NetCDF by aqdpWvs2nc:ncwrite_aqdpWvs.m V
',...
                version,' on ', datestr(now,0),'; PUV analysis run by ',...
                'aqdpWvs2nc:wad2puv.m V 1.2 on ',datestr(now,0),';
',history];
nc.history = ncchar(history_new);

% Close netCDF file
nc=close(nc);

disp(['Finished writing statistical wave parameters. ',num2str(toc/60),'
minutes elapsed'])

return
```

```
function ncwrite_aqdpWvs_raw(burstData, outFileRoot)
% ncwrite_adcpWvs_raw.m  A function to write Aquadopp pressure and velocities
%                         to a netCDF file.
%
%   usage:  ncwrite_aqdpWvs_raw(burstData, outFileRoot);
%       where:  burstData - a structure with the following fields
%                         burst - a vector of burst numbers
%                            dn - time, ML datenum
%                             p - pressure, m
%                             u - east velocity, m/s
%                             v - north velocity, m/s
%                             w - vertical velocity, m/s
%                             a - amplitude, counts
%               outFileRoot - a string specifying the name given to the
%                             NetCDF output files, in single quotes
%                             excluding the NetCDF file extension .nc
%
% Written by Charlene Sullivan
% USGS Woods Hole Field Center
% Woods Hole, MA 02543
% csullivan@usgs.gov
%
% Dependencies:
%   julian.m
%   gmin.m
%   gmax.m

% C. Sullivan   03/29/06,   version 1.2
% Reverse the chronology on the history attribute so the most recent
% processing step is listed first.  For spectra variables, calculate min
% and max attributes over time for each frequency.
% C. Sullivan   10/28/05,   version 1.1
% Provide the user additional feedback regarding code execution.  Add
% version number. Use NetCDF variable objects to write data to the NetCDF
% file.
% C. Sullivan   06/02/05,   version 1.0
% This function writes the raw pressures and velocities to the raw data
% NetCDF file.


version = '1.2';

disp(' ')
disp(['Writing pressure and velocity timeseries to ',outFileRoot,'r-cal.nc'])

nc=netcdf([outFileRoot,'r-cal.nc'],'write');

% Convert time from datenum to julian and get
% start_time, stop_time
nRec=length(burstData.dn(1,:));
for i=1:nRec
    dv = datevec(burstData.dn(:,i));
    time(i,:) = julian([dv]);
end
start_time=burstData.dn(1,1);
stop_time=burstData.dn(end,end);
```

```
% Convert velocities from m/s to cm/s for EPIC-compatibility
burstData.u = burstData.u * 100;
burstData.v = burstData.v * 100;
burstData.w = burstData.w * 100;

% Get the number of records
nRec = size(time,1);

% Get the number of samples
theSampleDim = nc('sample');
nSamples = size(theSampleDim);
nSamples = nSamples(1);

% Write data to netCDF file
% write coordinate variables
nc{'time'}(1:nRec, 1:nSamples) = floor(time);
nc{'time2'}(1:nRec, 1:nSamples) = (time-floor(time)).*(24*3600*1000);
nc{'burst'}(1:nRec) = burstData.burst;
nc{'lat'}(1)=nc.latitude(:);
nc{'lon'}(1)=nc.longitude(:);
nc{'sample'}(1:nSamples) = [1:nSamples]';

% write record variables
ncvarnames = {'hght_18','amp','u_1205','v_1206','w_1204'};
names = {'p','a','u','v','w'};
nNames = length(names);
for i = 1:nNames
    eval(['data = burstData.',names{i},';'])
    eval(['nco = nc{''',ncvarnames{i},'''};'])
    nco.maximum = gmax(data);
    nco.minimum = gmin(data);
    theFillVal = nco.FillValue_(:);
    bads = find(isnan(data));
    data(bads) = theFillVal;
    nco(1:nRec, 1:nSamples) = data;
    disp(['Finished writing ',nco.long_name(:)])
end

% Add the following netcdf file attributes
nc.CREATION_DATE = ncchar(datestr(now,0));
nc.start_time = ncchar(datestr(start_time,0));
nc.stop_time = ncchar(datestr(stop_time,0));

% Update the history attribute
history = nc.history(:);
history_new = ['Pressure and velocity timeseries converted to NetCDF by ',...
               'aqdpWvs2nc:ncwrite_aqdpWvs_raw.m V ',version,' on ',...
               datestr(now,0),'; ',history];
nc.history = ncchar(history_new);

% Close netCDF file
nc=close(nc);

disp(['Finished writing Aquadopp pressure and velocity timeseries. ',...
     num2str(toc/60),' minutes elapsed'])
```

```
return
```