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Providing Online Wave Data For the DanWEC Test Site

(DanWEC Vaekstforum 2011)

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Providing online wave data for the DanWEC test site
(DanWEC Vaekstforum 2011)

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J. P. Kofoed

AALBORG UNIVERSITY
Department of Civil Engineering

DCE Contract Report No. 138

Aalborg University
Department of Civil Engineering
Wave Energy Research Group

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Providing online wave data for the DanWEC test site

by

J. Lavelle & J. P. Kofoed

June 2012

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Preface

This report concerns the website created for DanWEC (Danish Wave Energy Centre), which gives public access to the data from the buoy located near Hanstholm and the weather station located on the harbour available to wave energy developers.

The website will allow the wave energy developers to get near-real-time access to the processed wave data. The website processes the data to obtain statistical wave parameters that characterise the sea conditions for thirty minute intervals.

The report gives a technical description about how the website was implemented, in addition to the mathematics behind the wave parameter calculations.

The work has been carried out by John Lavelle (AAU).

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1 Introduction

DANWEC will enable wave energy developers located at Hanstholm to share resources, in order to increase the rate of development of their devices while reducing costs. Hanstholm is located on the North West coast of Denmark; the location of the buoy is shown in Figure 1. The website that this document describes will allow developers to access the processed data from the buoy located near Hanstholm, data from the weather station at Hanstholm harbour and the water level in the harbour. As wave energy devices are dependent on the sea condition, the wave parameters are necessary for characterizing the device, in order determine its performance in situ and at other locations and scales.

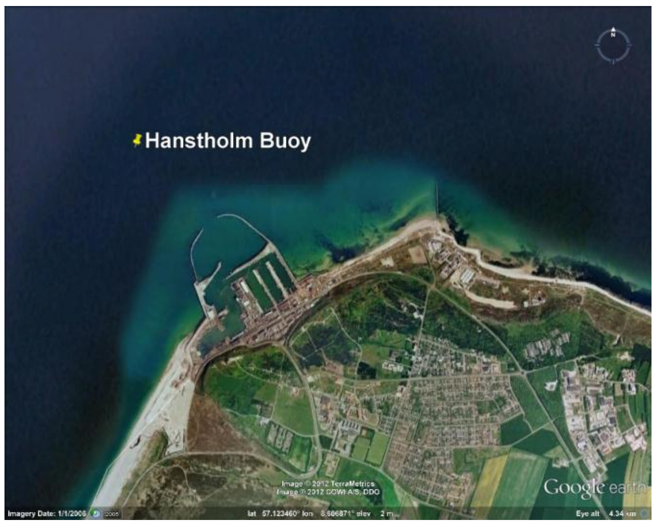

Figure 1: A Google Earth image showing the location of the Waverider buoy at Hanstholm.

The wave data is transmitted from the buoy to shore, processed and made available to the public on a website. The steps involved in this are as follows (also see Figure 2):

The data from the buoy (The specification and location of which is given in Appendix A.) is transmitted, via radio link, to the port of Hanstholm office. There, a PC running the data acquisition (DataWell) software stores the raw and processed data (see Appendix A). Whereas the time domain parameters that are calculated by the DataWell software are used by the website the frequency domain parameters are not (see Section 4).

The cloud computing platform, Amazon Web Services (AWS) (1) is used to deliver the website. The S3 AWS service is used for storage of the wave data and the EC2 AWS service is used for background processing and hosting the website.

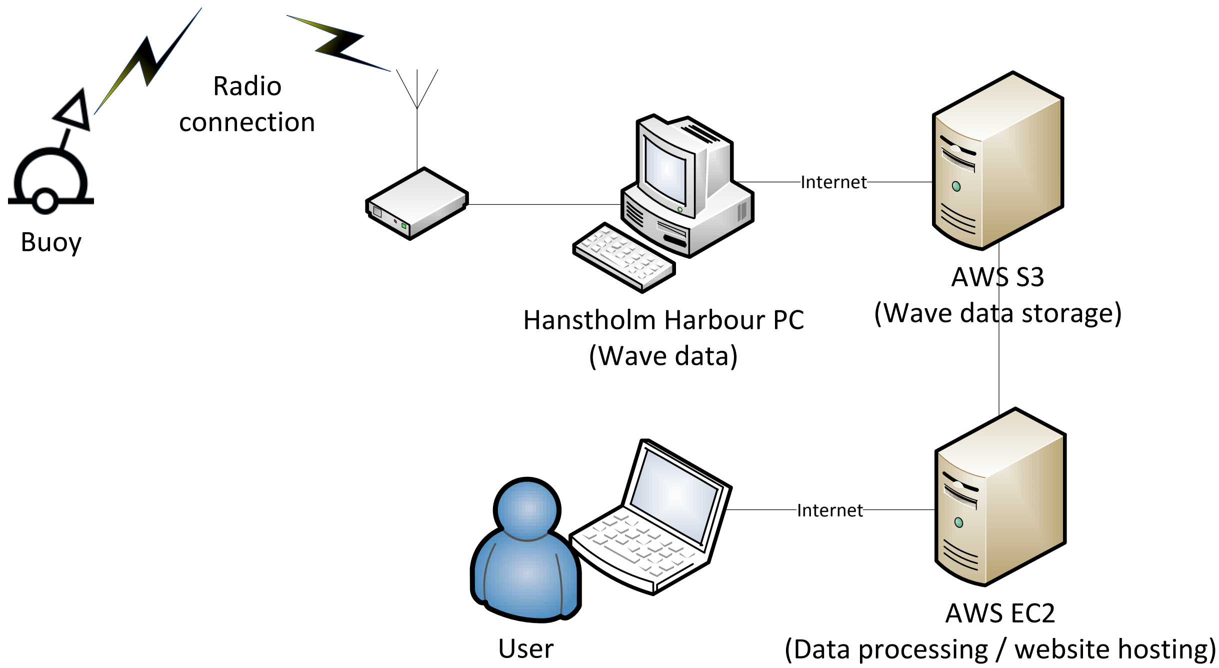

Figure 2: An overview of the steps involved in displaying the processed wave data on a website.

The wave elevation and time domain wave statics files on the PC at Hanstholm are uploaded to S3, using the Jungle Disk desktop software, at regular intervals (see Section 2).

The AWS EC2 instance (an Ubuntu virtual machine running on a server) is used to process the wave data and host the website. The website was written using the Web2py web application framework (see Section 3). Web2py runs a background service which processes the wave elevation data (retrieved from the S3 service) to calculate the frequency domain parameters (see Section 4.2) and store them in a SQLite database, together with the time domain parameters, on the EC2 storage. The Web2py website and background tasks are written using the Python programming language.

The weather station and water level data is accessible from www.hyde.dk. Every minute, this site is accessed and the data is added to the database.

The website displays plots of the wave and wind statistical parameters over the desired time period. The website also allows the numerical parameters data to be downloaded. A description of the website interface is given in Section 3. The website has been written in such a way to allow easy integration into the DanWEC website.

2 Wave Data Transfer and Storage in S3

The data acquisition software on the Hanstholm harbour PC produces ASCII files containing the wave elevation and time domain parameters at half hourly intervals, in the "C:\HanstholmHavn" directory. The Jungle Disk Desktop software uploads the wave elevation files (.1rw) and time domain parameters (.1wv) files to the "hamstholmwavedata" S3 bucket and has been configured to check for new files every five minutes. Figure 3 shows as screen shot of the Jungle Disk Desktop software, running on the PC that stores the buoy data.

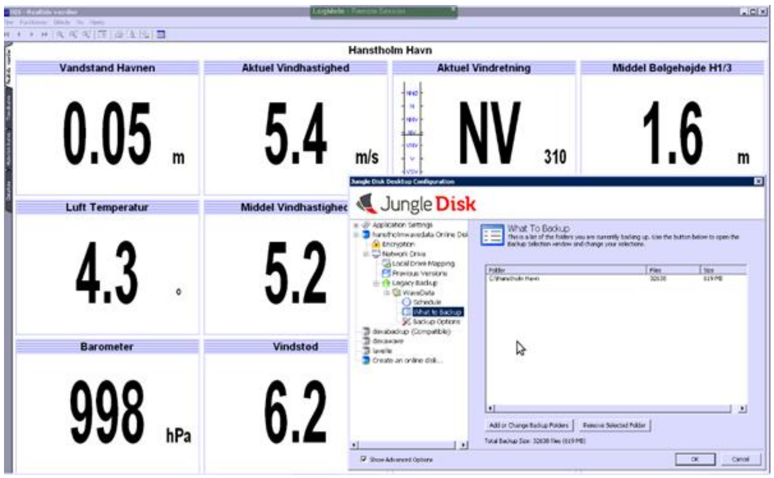

Figure 3 Screenshot showing the Jungle Disk Desktop software running on the Hanstholm Harbour PC

If it is necessary to reinstall Jungle Disk, it can be downloaded from (2). Ensure that the files are uploaded to a "compatible" S3 folder. Insert the Access Key ID and Secret Access Key, as described in Section 3. The AWS bucket name must match that used in S3todb.py (see Section 3.3).

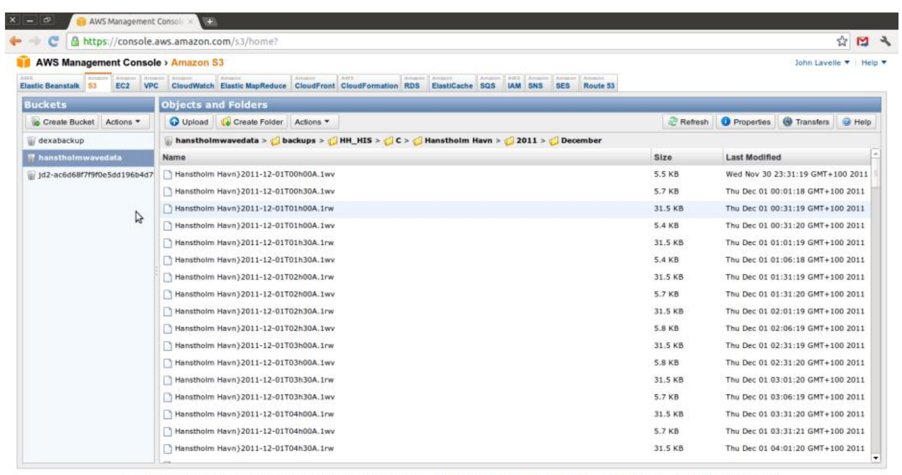

Figure 4: A screenshot of the AWS web interface, showing files uploaded to S3

The files containing the wave elevations and wave parameters are uploaded to the S3 service, as described in Appendix B. The S3 and EC2 AWS services can be accessed at (1), via a web interface. A screen shot of the AWS web interface for S3 is shown in Figure 4. Click on the S3 tab to see the files that have been uploaded.

3 Website Construction

The website runs on an AWS EC2 instance (i.e. virtual machine), which accesses the wave data from S3, processes it and puts it into a database. The website, which accesses this database, also runs on the instance.

3.1 AWS EC2

The instance used for the website is located in the "EU West (Ireland)" region. Select the EC2 tab and this region to start and stop this instance. The IP address for the instance can be found by selecting "Elastic Ips" in the AWS console (at the time of writing the IP for the website is http://79.125.119.134).

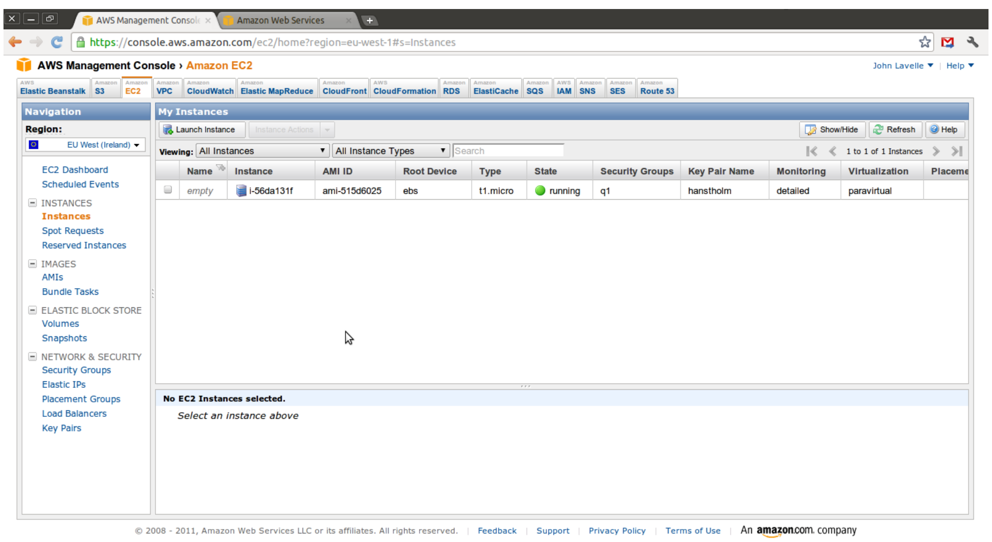

Figure 5: A screenshot of the AWS web interface, showing the Ubuntu instances which is hosting the website

The instance's command line can be accessed via SSH. This requires a key, which can be downloaded from the AWS security credentials pages under the "Key Pairs" tab. The key pair at the time of writing is "APKAJTOGCNVJO57LEEDA". See http://aws.amazon.com/documentation for documentation on how to use the key.

After logging into the instance, the website may be accessed by navigating the directory:

/home/www-data/web2py/applications/init/

The website software, web2py, should run automatically if the instance is restarted; however, for a fresh instance of reinstall, command line access is required to install web2py and the necessary python packages and start the background process, as described in Section 3.2.

3.2 Web2py and Python

The website was created using the web2py framework. Web2py is an open source framework, with extensive documentation, which can be found at http://web2py.com. The website is coded in a combination of HTML and Python. Documentation on Python can be found at python.org.

Web2py was installed an Ubuntu EC2 instance. Installation instructions can be found at http://web2py.com/books/default/chapter/29/13. Python 2.7 is installed on an Ubuntu instance by default. In addition to the standard Python packages, the following Python packages are required for the website:

- numpy
- scipy
- matplotlib
- pylab
- boto

They can be installed via the command line using apt-get (see http://www.ubuntu.com for the relevant documentation on apt-get).

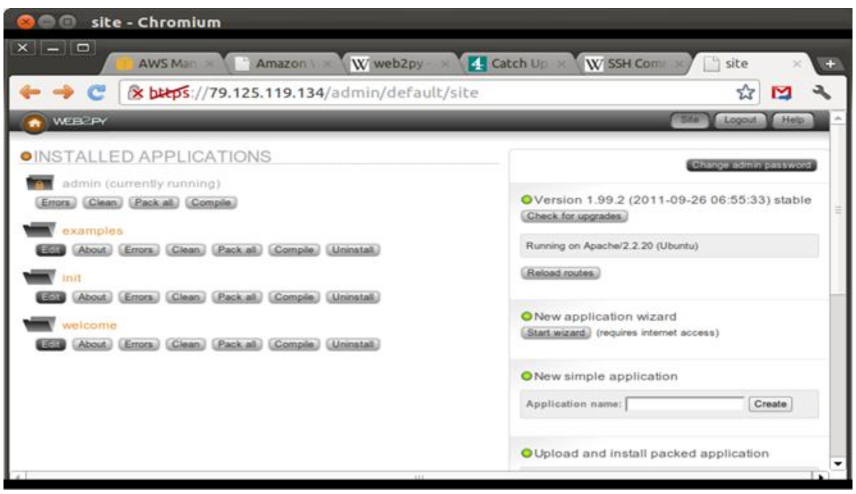

Figure 6: Screen shot of the web2py web IDE, showing the installed applications

Web2py has a web-based IDE, which can be accessed at https://79.125.119.134/admin, or on a local machine running a web2py server. (Note that the "s" in https is required.) The first page after logging in shows the installed web applications (see Figure 6). The website is called "init". It can be downloaded, for use on another server or a local machine, by clicking on "Pack All".

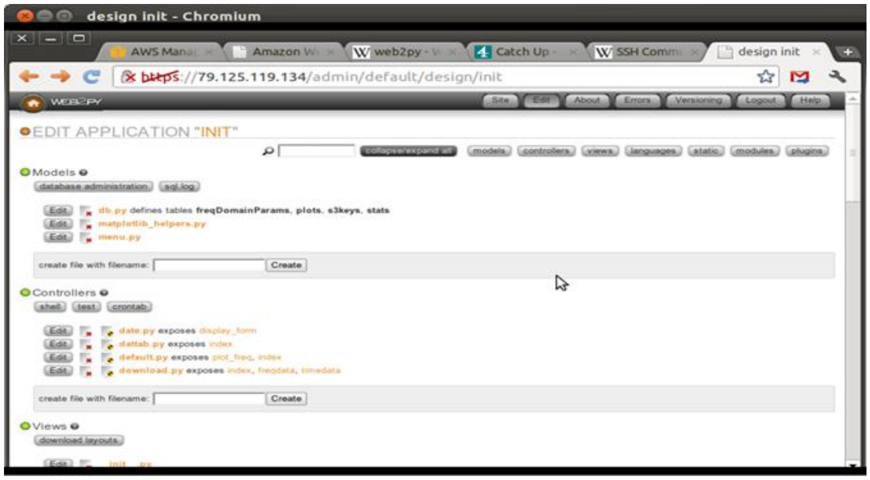

Figure 7: Screen shot of the web2py web IDE, showing the interface to view and edit the website code.

Click on “Edit” to view the website code, or if the application is installed on a local computer, look in the directory “/web2py/applications/init/” to view the source files. The code is organized into a Model, Controller, and View structure, as described in the web2py documentation. The important code for the website is as follows:

Models

db.py: creates the database tables

matplotlib_helpers.py: code to create plots of wave parameter time-series

Controllers

default.py: the code for the landing page, which shows plots of the data

download.py: the code for the page to download the wave data

Views

default/index.html : the html code for the landing page

download/index.html: the html code to the “Download” page

The function `plot_wave()` in default.py generates a plot (with the `plot()` function in matplotlib_helpers.py) of the specified parameter, over the specified time-span. This function is called in default/index.html to generate the plot as follows:

```
<img width="580px" src="{{=URL(f='plot_wave',args=[vars.start,vars.end,vars.Plot_1])}}" />
```

3.3 Background Processes

Wave Parameters

The background process (the Python programme S3todb.py) calculates the frequency domain wave parameters from the wave elevation data and inserts them, into the SQLite database, where they may be accessed from the website.

The code for the background process is located in:
/home/www-data/web2py/applications/init/private/S3todb.py

S3todb.py should run automatically if the server is rebooted. If necessary, it can be run as follows:
Change the directory to:

```
/home/www-data/web2py/
```

This background task is then executed via the command line with:

```
sudo python web2py.py -S init -a jj -M -N -R ./applications/init/private/S3todb.py -A a b c
```

S3todb.py is extensively commented, and overview of its functionality is given here:

An infinite while loop performs the following every 15 minutes:

- The boto Python package (3) is used to transfer the latest .1rw and .1wv files from S3.
- The frequency-domain parameters are calculated from the time series of the .1rw files as described in Section 4.2 and added to the database.
- The time-domain parameters from the 1wv files are added to the database.

A more mathematical description of how the wave parameters are calculated is given in Section 4.

Weather Stations and Water Level Data

The weather station data and water level data is available on hyde.dk. A cron job runs the program located in:
/home/www-data/web2py/applications/init/private/hydetodb.py
at 10 minute intervals. The program inserts this data into the table called weather in the database.

Crontab (Schedule tasks)

The crontab should be edited to run S3todb.py at reboot and following update the weather data table in the database every minute.

The crontab can be edited by type:

```
sudo crontab –e
```

in the command line. It should be edited as follows:

```
# m h  dom mon dow   command
* * * * * python /home/www-data/web2py/web2py.py -S init -a jj -M -C -J -N -
R ./applications/init/private/hydetodb.py
@reboot   python /home/www-data/web2py/web2py.py -S init -a jj -M -C -J -N -
R ./applications/init/private/S3todb.py
```

3.4 *Website Costs*

Table 1 shows the itemised costs of running the website (including AWS and Jungle Disk) for January 2012. The total cost for the website is approximately $1 per day or $365 per year. Currently, a Micro Instance is used for the computing on EC2. This type is only suitable for low volume sites. A larger instance may be required if the site gets significant amounts traffic. The next largest instance is a Small Instance, and with this type the total cost per month rises to $92.98. It is very simple to host the site on a larger instance, if required(1).

Item Description	Usage Amount		Unit Price		Cost After Tax
$0.00 per metric-month - first 10 metrics	6.99	$	-	$	-
$0.01 per 1,000 PUT, COPY, POST, or LIST requests	159.00	$	0.000	$	0.00
First 100,000 Amazon SNS API Requests per month are free	4.00	$	-	$	-
$0.010 per GB - regional data transfer	0.02	$	0.010	$	0.00
$0.140 per GB - first 1 TB / month of storage used	6.84	$	0.140	$	1.15
$0.11 per GB-month of provisioned storage	8.00	$	0.110	$	1.06
$0.14 per GB-Month of snapshot data stored	0.57	$	0.140	$	0.10
$0.000 per GB - first 1 GB of data transferred out per month	0.00	$	-	$	-
$0.000 per GB - data transfer in per month	8.36	$	-	$	-
$0.11 per 1 million I/O requests	1,098,858.00	$	0.000	$	0.14
$0.01 per 10,000 GET and all other requests	33,819.00	$	0.000	$	0.04
$0.025 per Micro Instance (t1.micro) instance-hour (or partial hour)	744.00	$	0.025	$	22.32
$0.120 per GB - up to 10 TB / month data transfer out	4.84	$	0.095	$	0.55
$0.01 per 1,000 PUT, COPY, POST, or LIST requests	176,964.00	$	0.000	$	2.12
$3 per month - Desktop data transfer software	1.00	$	3.000	$	3.00
Total				**$**	**30.48**

Table 1: AWS and Jungle Disk costs for one month (Prices are in US dollars). Currently, a Micro Instance is used, with a monthly cost of $30.48. With a Small Instance, the total cost per month rises to $92.98

The data storage cost is a relatively small percentage of the total, with the virtual machine (Micro Instance) accounting for the bulk of the cost. These costs are expected to reduce in the future, as they have in the past.

While cheaper solutions exist, AWS's prices are competitive (compared other providers such as Rackspace) at the time of writing, and provide a very reliable and flexible service. The website can be deployed on another provider's infrastructure if necessary. It is possible for instance to keep the AWS S3 storage, while moving the virtual machine to another provider. Another option would be to buy a dedicated server to host the site; however, the current trend is for websites owners to outsource their hardware requirements, using cloud computing platforms such as AWS. This tends reduce the costs, as the provider can fully utilise their hardware, and removes the need for the hardware to be maintained and upgraded at a future date.

4 Wave & Wind Parameters

The website provides both time- and frequency-domain parameters, which characterise the wave conditions for 30 minute intervals. The parameters are non-directional (i.e. they buoy does not measure directional wave information).

The DataWell software on the PC at Hanstholm automatically generates both files containing the time- and frequency-domain parameters. The files containing the time-domain parameters are upload to the S3 storage directly and then inserted into the website database. However, the frequency domain parameters calculated by the buoy are not used because, firstly, not all the parameters that are required are included (in the DataWell files containing the frequency domain data) and, secondly, as the spectrum of the waves is not available in any of the DataWell files, it is not possible to calculate the wave power directly. Therefore, the frequency domain parameters and wave power are calculated by transforming the wave elevation data (given in other files generated by the DataWell software) to the frequency domain, as described below.

4.1 Time-domain parameters

The software processes the latest thirty minutes of time series wave elevation data to obtain the parameters given in Table 2, which are written to a file with a ".1wv" extension (see Appendix A). The website's background task adds these parameters from the file to the database, so that they may be accessed by user.

Field	Unit	Description
Date and time	-	start of acquisition (Format: YYYY-MM-DD hh:mm)
H_{max}	cm	Height of the highest wave
T_{max}	s	Period of the highest wave
$H_{1/10}$	cm	Average height of 10% highest waves
$T_{1/10}$	s	Average period of 10% highest waves
$H_{1/3}$	cm	Average height of 33% highest waves
$T_{1/3}$	s	Average period of 33% highest waves
H_{av}	cm	Average height of all waves
T_{av}	s	Average period of all waves
Eps	-	bandwidth parameter
#Waves	-	Number of waves

Table 2: The wave data provided by the Datawell software

The parameters are calculated from the individual wave-heights and -periods, obtained from the wave elevation time series. Figure 8 shows a plot of a sample wave elevation time series from the buoy at Hanstholm harbour. It illustrates how the wave height, *H*, and period, *T*, are defined as the peak to trough distance and time period respectively of the individual wave. A wave is defined by two successive zero-up crossings.

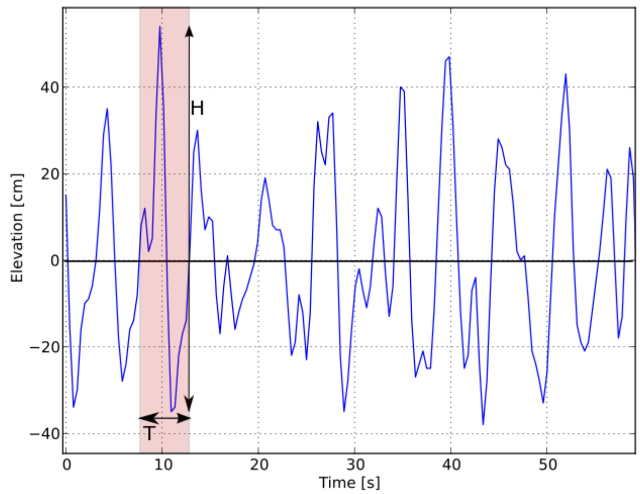

Figure 8: A sample wave elevation time series from the Waverider buoy at Hanstholm. Waves are defined by successive zero-crossings. A single wave is highlighted and labelled with its wave height, H, and period, T.

H_{max} and T_{max} are defined as the maximum wave height and wave period respectively of the individual waves in the thirty minute sample period.

The mean wave height, H_{av}, and mean wave period, T_{av}, are defined as follows:

$$H_{av} = \frac{1}{N}\sum_{i=1}^{n} \mathrm{H_i}, \quad T_{av} = \frac{1}{N}\sum_{i=1}^{n} \mathrm{T_i},$$

where *i* is the index of the wave.

$H_{1/3}$ and $H_{1/10}$ are defined as the average of the top one third and one tenth of the highest individual wave heights respectively. $H_{1/3}$ (or H_s) is more commonly used than $H_{1/10}$ and is known as the significant wave height. For narrow band seas, H_s (defined below) is approximately equal to H_{m0}.

$T_{1/3}$ and $T_{1/10}$ are the average of the top one third and one tenth highest waves respectively.

4.2 Frequency-domain parameters

Although both time and frequency domain parameters are provided on the website, the more modern, frequency domain parameters are now more commonly used, and considered more useful, in wave analysis.

Frequency-domain parameters are calculated by a background task, and inserted into the SQLite database (see Section 3.3). This section describes the methods used to calculate them.

Due to the fact that small amplitude wave elevations can be given by linear combination of sinusoids and cosines, the elevation time series may be transformed to the frequency-domain, to separate it into its constituent components(4). The omnidirectional Power Spectrum Density (PSD) function can be defined as:

$$S(f) = \frac{\Delta E}{\Delta f}$$

where ΔE is the variance.

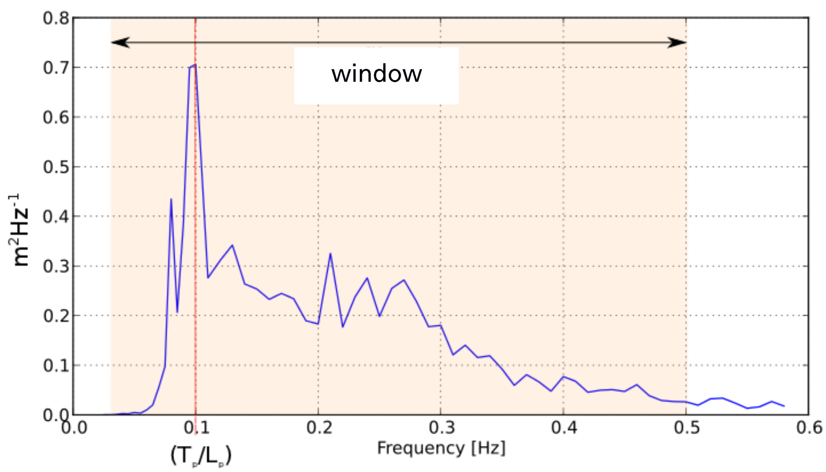

Figure 9: An example plot of the PSD of the wave elevations. The frequency corresponding to T_p and L_p is shown

The PSD is calculated using the "psd" function from the Matplotlib Python package. For improved accuracy, the function splits the time domain data into sequences of the specified length, where the sequences can overlap, and then uses Fast Fourier Fourier Transform (FFT) to transform to the frequency domain(5).A sequence length of 512 and an overlap of 20% was chosen.

The frequency domain parameters given in the website are expressed in terms of moments of the spectral density function, $S(f)$. The n^{th} spectral moment is defined as:

$$m_n = \int_0^{\infty} f^n \widehat{S(f)} df$$

where $\widehat{S(f)}$ is $S(f)$ filtered using a windowing function, as in practice, when the moments are calculate, the PSD must be filtered, due to noise.$S(f)$ is filtered with the windowing function as follows:

$$\widehat{S(f)} = \begin{cases} S(f)\,, F_p/10 < f < 10F_p \\ 0,\ \text{else} \end{cases}.$$

This filtering is especially important for the higher order modes, where noise in the PSD can cause them to be too large.

The parameters in Table 3 are calculated by the background task (see Section 3.3).

Symbol	Unit	Title	Moment definition
H_{m0}	[m]	Significant wave height	$4\sqrt{m_0}$
T_e	[s]	Energy wave period	m_{-1}/m_0
$T_{0,1}$	[s]	Mean wave period	m_0/m_1
$T_{0,2}$ or T_z	[s]	Zero-crossing wave period	m_2/m_0
T_p	[m]	Peak wave period	None
ε	[-]	The spectral bandwidth	$\sqrt{1-m_2{}^2/m_0m_4}$
L_p	[m]	Peak wavelength	None
P_w	[W/m]	Wave power	None

Table 3: Frequency domain wave parameters provided by the website

The significant wave height, H_{m0}, is approximately equal to the time domain parameter $H_{1/3}$., for a narrow spectrum of wave.

T_1 is the inverse of the average frequency of the spectrum.

T_2 is the average period of the zero-upcross waves.

T_p is the period at which the PSD in maximum (indicated in Figure 9).

ε is the bandwidth parameter, which goes from 0 for narrow band to 1 for wide band.

L_p is the peak wave period (indicated in Figure 9). It is calculated using the dispersions relationship (as deep water cannot be assumed)as described below.

P_w is the non-dimensional power in the waves and is given by:

$$P_w = \rho g \int_0^\infty \widehat{S(f)} c_g(L(f))df,$$

where ρ is the density of the water (assumed to be 1025 kg/m^3), g is the acceleration due to gravity (9.81 ms^{-1}), c_g is the group velocity of water as a function wave frequency, f (4) and $L(f)$ is the wavelength.The group velocity is given by:

$$c_g = \frac{c}{2}\left(1 + \frac{4\pi h}{L(f)} \Big/ \sinh\frac{4\pi h}{L(f)}\right),$$

where c is the phase velocity, given by:

$$c = f\,L(f).$$

Whereas a direct, analytical, solution exists between wavelength and wave frequency when deep water is assumed, an iterative method is necessary to calculate wavelength from the wave frequency in shallow water, as is the case for the location of the buoy at Hanstholm(4)(6).

The wavelength and frequency are related by the dispersion relationship, as follows:

$$\omega^2 = gk \tanh kh,$$

where ω is the angular frequency ($2\pi f$), k is the wave number ($2\pi/L(f)$) and h is the water depth. Rearranging and substituting $L(f)$ is given by:

$$L(f) \ = \frac{g}{2\,\pi f^2} \tanh \frac{2\,\pi\,h}{L(f)}.$$

This function is initialized with an initial estimate for $L(f)$ on the RHS of the equation of g/f^2, to obtain new estimate of $L(f)$. In subsequent iterations, the new estimate is obtained using the value of $L(f)$ from the previous iteration for the value of $L(f)$ on the RHS. The algorithm converges to a solution. In the implementation for the website, the algorithm stops when the difference between successive estimates of $L(f)$ is less than 5×10^{-3}.

As the calculation of c_g is somewhat computationally intensive (due to the computation of $L(f)$) and is required for processing each of the wave elevation files by the website's background task, the computed values are stored and reused.

4.2.1 Filtering of the wave data

A proportion of the wave-elevation time series inevitably contains some erroneous values. This spurious data is caused by myriad reasons, including malfunctioning of the buoy electronics, knocks from floating object and transmissions errors (4). Filtering of the data is important; however, discriminating the erroneous from the accurate data values is challenging as it can take many forms, including spikes and constant non-zero elevation values.

Figure 10 shows plots of the wave data for a selected time series. Figure 10 Top Left shows a plot of elevations versus velocity. Both elevations and velocity of the waves should be normally distributed. The velocity, v, is given by:

$$v_i = \frac{\eta_i - \eta_{i-1}}{dt}$$

where η are the elevations and dt is the sampling interval. Both the elevations and velocity are used to discriminate the erroneous values (4).

Real ocean waves have normally distributed values of η and v. The values of η and v vectors, shown in Figure 10 Top Right, are decomposed into orthonormal vectors (i.e. factorized) using Scalar Vector Decomposition (SVD), as shown in Figure 10 Bottom Right, making it easier to discriminate the erroneous values. The standard deviation of both the *x* and *y* coordinates (shown in Figure 10 Bottom Right) are calculated. Values greater the four standard deviations in both *x* and *y* are indentified as erroneous values. The erroneous values in η are replaced with the interpolation of the two adjacent values. Finally the Shapiro test for normality (7) is applied to the x and y coordinates of the new elevation and velocity vectors (with erroneous values corrected for). The Shapiro test gives a metric with values close to 1 for normal distributions; with values less a 0.95 for the x or y coordinate, the time series is rejected and the parameters for it are not added to the database.

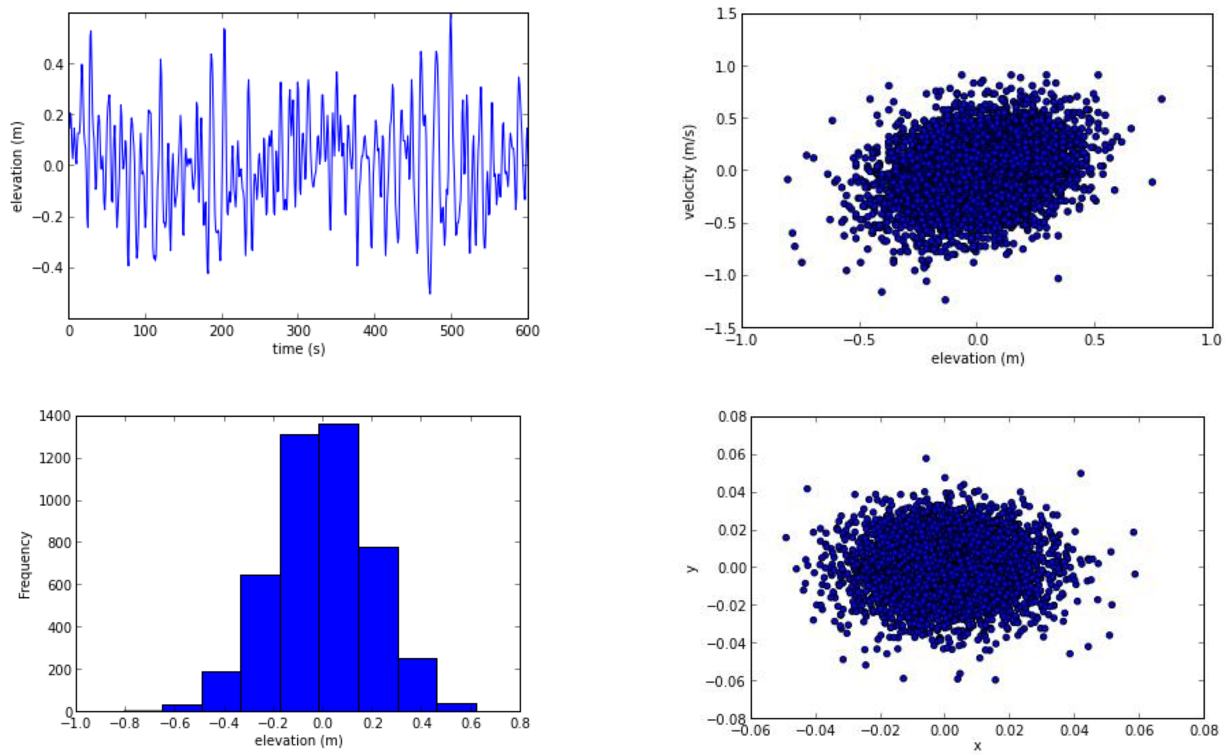

Figure 10: Top Left: A plot of a selection of the time series data. Top Right: A scatter plot of the elevation versus velocity data, using the full 30 minutes of time series data. Bottom Right: A histogram of the wave elevations. Bottom Right: The wave velocity and wave elevations transformed to new coordinates using SVD.

4.3 Meteorlogical and water level data

The wind data is measured using an anemometer (see Figure 11). The data is continuously transmitted to www.hyde.dk. The following data from the www.hyde.dk website is added to the Hanstholm Wind and Wave website database:

Parameter	**Unit**
End sample time (UTC)	-
Water level	m
Mean wind speed	m/s
Wind direction	degrees
Wind gust	m/s
Pressure	bar
Temperature	degrees centigrade

These parameters are the mean values for each ten minutes. Whereas the time stamps from the wave data is the time at the start of the sample period, the time stamp for the weather and water level data corresponds to the end of the sample period.

Long-term plots of statistics of the wind data from the anemometer can be obtained from www.wavefinder.com, as shown in Figure 12. This website provides an interface to enable plots to be embedded in another website.

Figure 11: A photo Hanstholm Harbour Port offices. The mast with the anemometer which records the wind data is to the right of the building.

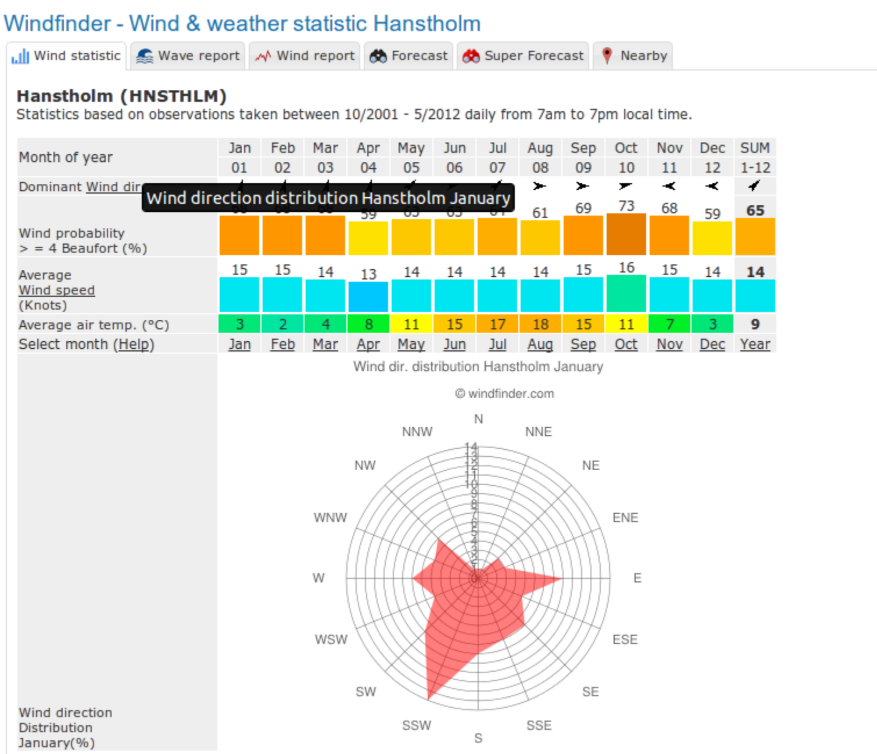

Figure 12: A screenshot of the www.windfinder.com website, showing statistics for the wind data at Hanstholm.

5 Website Interface

The website allows either user to plot or download the wave data directly, or for the plots to be embedded in another website.

5.1 User Interface

The website's landing page (shown in Figure 13) gives plots of both the frequency and time domain parameters with the parameter calculated from half hourly time-series. The parameters to plot and timespan may be selected.

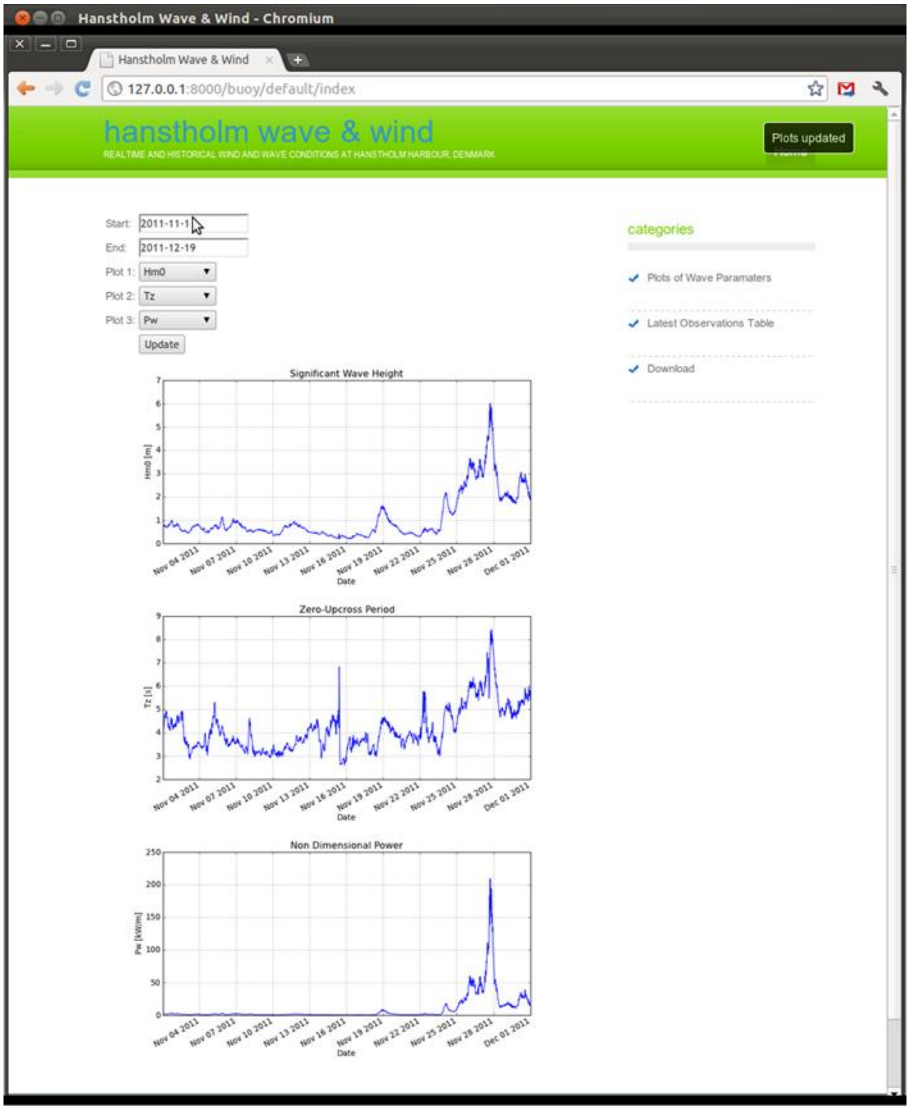

Figure 13: A screenshot of a page from the website, which shows plots of the wave parameters

Click on the "Download" link to download the wave data. When the time-span for desired the data is selected, links for the CSV (Comma Separated Value) files are generated for both the time- and frequency-domain parameters.

5.2 Computer Interface

The plots of the wave data may easily be integrated into another website by are parsing the URL of the plots, as follows:

https://79.125.119.134/init/default/plot_wave/<start date>/<end date>/<Paramater>

where<start date>and<end date> have the format YYYY-MM-DD and the parameter is one of the frequency- or time-domain parameters listed in Table 2and Table 3 in Section 0. The following URL generates a plot of Hm0 from 2011-11-10 to 2011-12-19:

https://79.125.119.134/init/default/plot_wave/2011-11-10/2011-12-19/Hm0

Similarly, a CSV of the frequency-domain parameters over the same range is generated with:

http://79.125.119.134/init/download/freqdata.csv/<start Date>/<end Date>/<Paramater>

and the time-domain parameters by:

http://79.125.119.134/init/download/timedata.csv/<start Date>/<end Date>/<Paramater>

5.3 Third party Hanstholm wave data resources

A Mike 21 model for the waves at Hanstholm has been produced by DHI. The model is give short term predictions of the wave conditions. A site with the forecast is available at:

http://130.226.168.37/WF/DashboardEngine.aspx?DashboardID=Hanstholm\Locations

Permission from DHI should be sought before embedding images or linking from this site the into the DanWEC website.

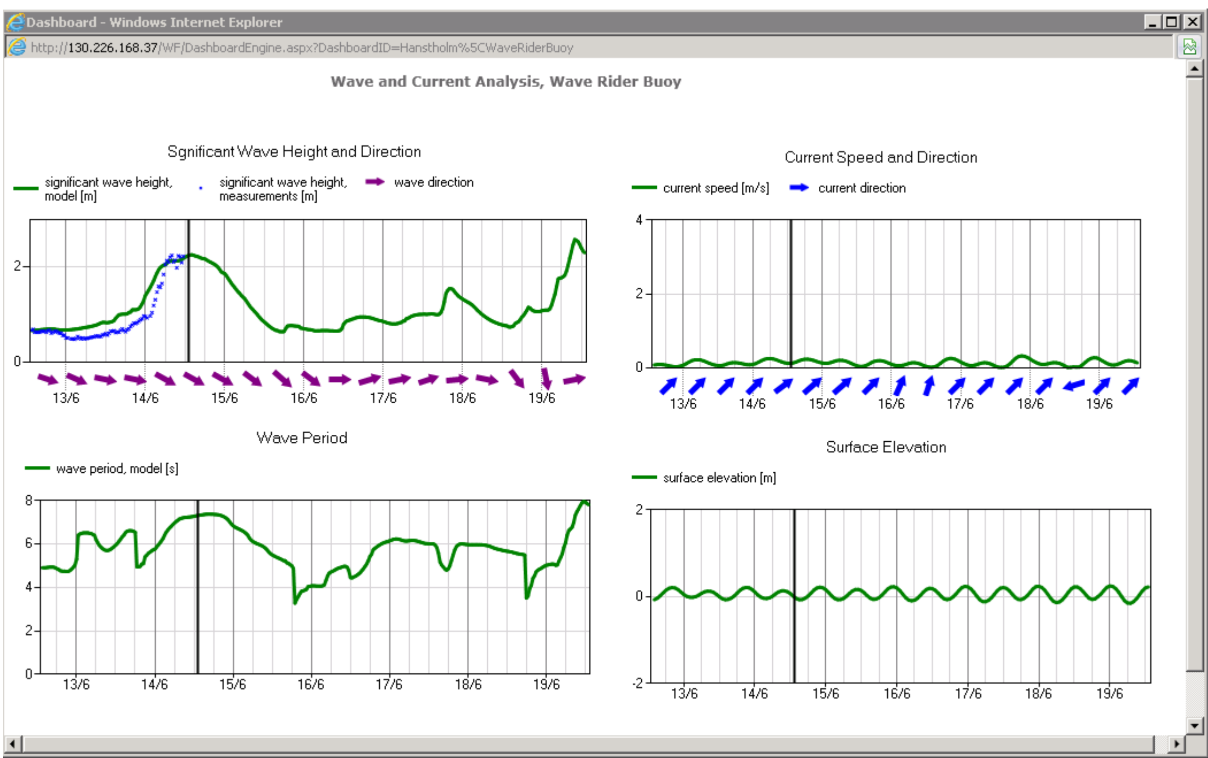

Figure 14: A screen shot of the DHI website which gives wave forecasts at Hanstholm

Appendix A. Waverider Buoy

The specification and details of the file formats are given here.

Table 4: A photograph of the DataWell waverider buoy

Model	Data Well mark II (Non-directional)
Coordinates	Latitude 57.1315°, Longutude8.5821°,
Mean water depth at buoy location	17.5m
Station Number	1022

Table 5: Details on the buoy at Hanstholm

File Formats

The following files are uploaded from the “C:\HanstholmHavn” directory on the PC at Hanstholm harbour to Amazon's S3 storage (8):

Extension: .1rw

Contents: ASCII text with 20 minutes of displacement data, with a sample rate of 2.56 Hz (one line per displacement value).

One file is generated each half hour

Extension: .1wv

Contents: ASCII file with 30 minutes of time-domain statically data. The following is from the Data Well website (8).

The first line consists of Wave Statistic parameters calculated from buoy data. The values are stored comma separated in the following order:

Date and time (start of acquisition)	[YYYY-MM-DD hh:mm]
Percentage of data with no reception errors	[%]
Hmax (Height of the highest wave)	[cm]
Tmax (Period of the highest wave)	[s]
H(1/10) (Average height of 10% highest waves)	[cm]
T(1/10) (Average period of 10% highest waves)	[s]
H(1/3) (Average height of 33% highest waves)	[cm]
T(1/3) (Average period of 33% highest waves)	[s]
Hav (Average height of all waves)	[cm]
Tav (Average period of all waves)	[s]
Eps (bandwidth parameter)	-
#Waves (Number of waves)	-

The remaining lines contain the values per wave. Line (row) j (= chronological index) has four numbers:

i (index)	-
Crest	[cm]
Trough	[cm]
Period	[s]

The meaning of i for *.wvs files: wave j is the i^{th} wave by height.

The meaning of i for *.wav files: wave i is the j^{th} wave by height.

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