Processing of wave data from pressure sensors

Introduction

This set of routines processes data from pressure sensors to compensate the attenuation of pressure variations with depth and compute the standard (non-directional) wave parameters. These are Matlab routines, that means Matlab must be installed in order to use them.

wavesp.m computes the spectral wave-parameters after correction of the pressure attenuation. If pr_corr.m and zero_crossing.m are on the matlab-path, the zero-crossing wave-parameters are also returned.
pr_corr.m returns the attenuation-corrected water surface. It is called by wavesp.m for the zero-crossing wave-parameters.
zero_crossing.m computes the zero-crossing wave-parameters. It is called by wavesp.m.

Full help how to use is included in the comments at the beginning of each routine.

Disclaimer – I have written these routines with care and I use them myself for my research. However, I cannot give any guarantee for the accuracy of their results.

Download

To download the 3 routines in a zip-file, use following link

waves.zip (9 kB)

To download separately the 3 routines, right-click on the following links and select "Save target as..."

wavesp.m (version 1.11, 9 kB)
pr_corr.m (version 1.09, 8 kB)
zero_crossing.m (version 1.06, 6 kB)

Detailed description

- The routines use the standard calculations methods, as described in Tucker and Pitt (2001).They correct the attenuation of pressure variations with depth
- The input arguments are the uncorrected water heights above bed in metre, as obtained from the calibrated pressure-sensor data, the height of the pressure sensor above bed, the sampling frequency, and some possible options.
- The attenuation correction is only applied over a given frequency range to avoid to over-amplify high frequency variations that do not correspond to surface waves but are some noise. By default the correction is applied over the range 0.05-0.33 Hz. This range can be modified by an input argument. In addition, the maximal correction factor is set to 5 (this value may be modified for some special cases, but this is not recommended). In order to fully understand these concepts, the users should look at the correction factor returned by pr_corr with first argument an empty matrix.
- Traditionally, record lengths of a power of 2 were used to have an optimum computing speed in the Fast Fourier Transform algorithm. However, with the calculation power of modern personal computers, this restriction is not longer necessary, and wavesp and pr_corr perform fast enough with any record length.

- **Wavesp** and zero_crossing ignore the first data column if all its values are between 720000 and 740000 (range of matlab date-time values).
- Wavesp divides the input vector in overlapping segments that are processed separately and the results of which are averaged. By default the segment length is 1/4 of the input-vector length. For short input vector, the number of segments can be reduced, e.g. by selecting a segment length of 1/2 (4th argument "2").
- Wavesp called without output argument prints the wave parameters in the matlab command window and create a figure with the spectral density of the waves.
- Wavesp returns as optional third output argument a 2-column matrix with the spectral density and the corresponding frequencies.
- Wavesp accepts also as input a matrix or a cell array. The height of the sensor above bed can be either a scalar or an array with one value for each column of the matrix / each element of the cell array. This allows to process either an array of pressure sensors that were recorded in one file, or successive time-interval from the same pressure sensor.
- An option of Wavesp selects which wave parameters are returned: some or all spectral parameters, all or none zero-crossing parameters.

- **Pr_corr** return a vector with the same length than the input vector. The vector length does not have to be a power of 2. The input vector can contain NaN values (indicating missing data or emersion in intertidal setting). They will be ignored during the processing, but returned at the same position in the output vector.
- Pr_corr divides the input vector in overlapping segments (by default 512 records long) that are processed separately and then recombined.
- Pr_corr takes as input either a detrended sea surface elevation and the mean water depth, or the sea-surface above bottom. The latter case, each segment will be linearly detrended, corrected for attenuation, and the linear trend added back before constructing the output vector. This usage is very powerful, because a time series of several hours can be processed in one call to pr_corr.
- Pr_corr accepts also a matrix. In this case each column is processed separately. The height of the sensor above bed can be either a scalar (same value for all columns) or an array with one value for each column. This allows to process an array of pressure sensors that were recorded in one file.
- Pr_corr can also return the correction factor for each wave frequency that is used to compensate the depth attenuation.

- **Zero_crossing** takes as input argument the true water elevation time-series. If pressure-sensor data are used, they must be corrected with pr_corr before. Therefore it is easier to simply call wavesp, which will then call pr_corr and zero_crossing.
- Zero_crossing called without output argument prints the wave parameters in the matlab command window and creates a figure with histograms of wave heights and wave periods.
- Zero_crossing can also return the height and period of each wave in the original order, which is useful to analyse special wave events.

- Explanation of the calling syntax for each routine is obtained by typing "help wavesp", "help pr_corr" or "help zero_crossing" at the Matlab prompt.

Examples of usage

wavesp

wavesp(data,0.5,4)	simple use, with sensor 0.5 m above bed and sampling frequency 4 Hz
wavesp(data,0.5,4,[0.05 0.45])	with pressure correction over the frequency range 0.05-0.45 Hz
wavesp(data,0.5,4,'az')	returning all spectral parameters and the zero-crossing parameters
wavesp(data,0.5,4,[],2)	divide data in segments of 1/2 instead of 1/4

[parameters,names]=wavesp(...)	returning parameters (row array) and their names
[parameters,names,spectrum]=wavesp(...)	returning also the wave spectrum
pr_corr	
surface=pr_corr(data,2.6,4,0.5)	simple use, with mean water depth 2.6 m, sampling frequency 4 Hz and sensor 0.5 above bed
surface=pr_corr(data,[],4,0.5)	with undetrended data (sea-surface above bottom)
surface=pr_corr(data,2.6,4,0.5,[],[0.05 0.45])	with pressure correction over the frequency range 0.05-0.45 Hz
correction=pr_corr([],2.6,4,0.5)	return the correction factor used to compensate the depth attenuation.

Wave parameters computed by wavesp and zero_crossing

spectral wave-parameters	
m_0	Total variance Wave energy = water-density · g · m_0
H_{m0}	significant wave height by spectral method
T_p	Peak period
T_{01}	average period m0/m1
T_{02}	average period (m0/m2)^0.5
T_{pc}	calculated peak period
EPS2	spectral width parameter
EPS4	spectral width parameter
zero-crossing wave-parameters	
H_s	Significant wave height
H_{mean}	mean wave height
$H_{1/10}$	height of highest 10%
H_{max}	maximum wave height
T_{mean}	mean wave period
$T_{significant}$	mean period of highest 33%

Reference

Tucker M.J. & Pitt E.G. (2001) Waves in ocean engineering. Elsevier ocean engineering book series vol. 5, Elsevier, Amsterdam, 521 p.

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