Wave Post Processing Description

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Introduction

This application note contains a detailed explanation of the Falmouth Scientific, Inc. (FSI) WAVEPOST post processing software. It will explain how the Wave Height and Direction are computed.

The FSI 3DACM WAVE collects pressure data in millibars and the velocity data in cm/s. The 3DAcm97 software downloads data from the 3DACM WAVE and stores the data in ASCII comma delimited format. WavePost reads the ASCII data into memory and applies the following steps to the data in the order they appear:

1. Subtract the atmospheric pressure value from the pressure data.
2. Convert the pressure data from millibars to decibars by dividing by 100.
3. Convert the cm/s velocity to m/s velocities by dividing by 100.

Non Directional Pressure Analysis

1. Determine the average of the data set. (one data set is the determined by the Properties dialog and is either 512, 1024, 2048 or 4096 data points)
2. Use the average pressure value as the instrument measurement depth (for depth correction).
3. Calculate the water depth by the “Height off the Bottom” setting from the Properties dialog to the instrument measurement depth.
4. Next, determine the number of data segments within the data set using a data segment length of 512 points and 50% overlapping. Example: Nseg=(1024 / (512 – 512 / 2)) –1 = 3 segments.
5. Apply the following steps to every data segment and accumulate the resultant spectrum:
    a. Remove the mean from this segment
    b. Remove any linear trend
    c. Apply a 10% cosine taper to the pressure data
    d. Maintain variance
    e. Perform a 512-point FFT
    f. Calculate the magnitude of each frequency bin until Nyquist
    g. Accumulate each frequency bin with last segment frequency bin
6. Divide each frequency bin by the number of segments for this data set, Sxx.
7. If depth correction is NOT used go to step 10, other wise go to step 8.
8. Determine wave number in radians/meter from the sampling frequency and the water depth.
9. Apply the depth correction to the spectrum series, Sxx.
10. Calculate the Wave Height using the following:

$$Hmo = 4.0 * \sqrt{\sum_{n=0}^{255} Sxx(n)} \quad \text{(meters)}$$

11. Search Sxx to determine the peak frequency and peak period.
12. Calculate the spectral moments m0, m1, m2.

$$m0 = \sum_{n=0}^{255} Sxx(n), \qquad m1 = \sum_{n=0}^{255} f(n) * Sxx(n), \qquad m2 = \sum f^2(n) * Sxx(n)$$

13. Calculate the average wave period, Tavg = m0 / m1
14. Calculate the zero-crossing period, Tzero = $\sqrt{m0/m2}$
15. Now determine the maximum wave height using time series analysis. Follow these steps:
    a. Remove the mean from this data set.
    b. Remove any linear trend.
    c. If depth correction is NOT on goto to step h.
    d. Determine wavenumber in radians/meter from the sampling frequency and the water depth.
    e. Take the FFT of the time series.
    f. Apply the depth correction
    g. Take the IFFT of the corrected frequency response.
    h. Determine zero-crossing period using time series data.
    i. Determine Maximum wave height and the period of the maximum wave.

Directional Analysis

1. Determine the average of the pressure, north velocity and east velocity data set. (one data set is the determined by the Properties dialog and is either 512, 1024, 2048 or 4096 data points)
2. Use the average data value as the instrument measurement depth (for depth correction).
3. Calculate the water depth by the "Height off the Bottom" setting from the Properties dialog to the instrument measurement depth.
4. Next, determine the number of data segments within the data set using a data segment length of 512 points and 50% overlapping. Example: Nseg=(1024 / (512 – 512 / 2)) –1 = 3 segments.
5. Apply the following steps to every data segment and accumulate the resultant Co-Spetra for Cpres, Cnorth, Ceast, Cpres_north, Cpres_east, Cnorth_east:
    a. Remove the mean from this segment
    b. Remove any linear trend
    c. Apply a 10% cosine taper to the data sets
    d. Maintain variance
    e. Perform a 512-point FFT
    f. Calculate the co-spectra of each frequency bin until Nyquist for the pressure, north and east velocities
    g. Accumulate each co-spetra bin with last data segment
6. Divide each co-spetra frequency bin by the number of segments for this data set, Cpres, Cnorth, Ceast, Cpres_north, Cpres_east, Cnorth_east.
7. If depth correction is NOT used go to step 10, other wise go to step 8.

8. Determine wavenumber in radians/meter from the sampling frequency and the water depth.
9. Apply the depth correction to the spectrum series, Cpres, Cnorth, Ceast, Cpres_north, Cpres_east, Cnorth_east.
10. Determine direction coefficients a0, a1, b1, a2 and b2 (n=0..255).

$$a0(n) = Cpres(n)/\pi$$

$$a1(n) = Cpres\_north(n)/\pi/(2*\pi*f(n))$$

$$b1(n) = Cpres\_east(n)/\pi/(2*\pi*f(n))$$

$$a2(n) = (Cnorth - Ceast)/\pi/(2*\pi*f(n))^2$$

$$b2(n) = (Cnorth\_east)/\pi/(2*\pi*f(n))^2$$

11. Determine the mean wave direction:

$$MWdir = a\tan 2(b1(findex), a1(findex))$$

where findex is the peak frequency index.

12. Compute the direction array for plotting the direction data:

$$Dir\_Array(n,m) = \begin{array}{l} a0(n) + ... \\ a1(n)*\cos(\theta(m)) + ... \\ b1(n)*\sin(\theta(m)) + ... \\ a2(n)*\cos(2*\theta(m)) + ... \\ b2(n)*\sin(2*\theta(m)) \end{array} \qquad (m^2/Hz/\deg ree)$$