CALIBRATION ACCURACY AND DATA CORRECTION
FOR WAVERIDER BUOYS DEPLOYED DURING ARSLOE

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Abstract

During the Atlantic Remote Sensing Land Ocean Experiment (ARSLOE), Oct.-Nov., 1980, a large number of meteorological and oceanographic instruments, especially wave-measurement instruments, were deployed in the ocean near the Army Corps of Engineers Pier, Duck, NC. About 9 Waverider¹ buoys were deployed in an approximately rectangular pattern, about 30 km wide by 40 km seaward. The Waveriders were an accepted reference for study of other wave measurement instrument systems. Almost all of the Waverider buoys were calibrated on the rotating-arm facility of the NOAA, Engineering Support Office. Pre- and post-deployment calibrations formed the basis for tables and equations for correction of the Waverider measurements. The calibrations discussed here established that the Waveriders were measuring lower than specification, averaging about 5 percent low (10 percent for variance spectra coefficients.) Corrections for effects of fluctuations in water temperature on Waverider sensitivity were required and are provided. The manufacturer's modification to prevent future drift in sensitivity is also described.

1. Introduction

Waverider buoys have been in use since about 1962 and are the principal instrument for national wave measurement programs for many countries. It has been frequently assumed that the Waverider sensitivity remains within 3 percent of specified one volt per meter of wave elevation throughout the useful life of the Waverider. For a number of years, no calibration apparatus was available which could accept a complete Waverider buoy, although approximate calibrations over limited range of period of vertical motion could be obtained by suspending the buoy from an elastic cord or spring and maintaining vertical oscillations manually.

Canada, England and the United States now have apparatus to calibrate Waveriders on a rotating-arm, vertical circle of motion. Venezuela has apparatus for generating pure

vertical motion. Such devices can improve ocean wave measurement accuracy by determining error, possibly on the order of a few percent, in Waverider sensitivity versus period of motion. Resultant correction factors are a function of period or frequency and, therefore, must be applied to sinusoidal, Fourier components of a waves elevation time series or, as square of the transfer function, to the coefficients of the variance spectra.

The Waverider has a unique accelerometer design consisting of a cantilever-beam sensor mounted in the electrical field of an electrolytic fluid. The fluid conductivity has been carefully adjusted to provide the desired Waverider sensitivity and circuitry is designed to match the accelerometer characteristics. Under the design conditions, effect of fluctuations of temperature of this electrolyte fluid can be considered negligible. However, increase in the electrical conductivity of the electrolyte of some Waveriders has caused a corresponding decrease in sensitivity and has made the assumption of insensitivity to temperature fluctuations no longer valid. This has increased the importance of applying corrections to Waverider measurements. Correction tables are available for the Waverider buoys used in the ARSLOE.

2. Waveriders Accuracy Characteristics

All of the Waveriders used in the ARSLOE telemetered to individual Datawell WAREP[®] receivers. Receiver errors were small compared to the buoy errors, but all of the receivers have an accuracy characteristic response at higher frequencies (figure 1) which is included in the calibration of the buoys (van Breugel). Receivers were calibrated with a WAREP test unit manufactured by Datawell. The test unit was checked with a counter-timer. Thus, traceability was established.

The buoys, exclusive of receiver accuracy, have a characteristic as illustrated in figure 2 (Verhagen et al 1975.) At the higher frequencies the deviations are caused by a combination of buoy hydrodynamic resonance and other effects and are

¹Waverider and WAREP are Datawell proprietary names for the buoy and receiver system, respectively

Figure 1.—WAREP High Frequency Characteristic

not included in calibrations. The remaining, lower frequency, deviation (Δ) of figure 2 is systematic, represented by equation 1, (Datawell, 1976.) Deviations (δ) from the relationship of equation 1 were obtained by calibration. A polynomial of second order in period was

$$\Delta = \frac{1}{\left[1 + \left(\frac{T}{30.8}\right)^4\right]^{1/2}} \quad (1)$$

fitted to the calculated values of δ and used to provide correction tables (Ribe, 1981) versus period and frequency. Corrections for variance spectra coefficients are also provided.

Figure 2.—Buoy Frequency Response

The Waverider also causes phase shifts on the individual Fourier components of wave records in a systematic manner (Verhagen et al, 1975.) Corrections for these phase shifts are necessary if wave records are used to study wave shapes.

3. Buoy-Accuracy Stability and Temperature Effects

All of the Waverider buoys used in ARSLOE exhibited sensitivity below 100 percent, averaging approximately 95 percent of the rated one volt per

meter of wave height. Sensitivities are determined after correction for the Datawell-specified decrease of sensitivity with increasing wave period, which is non-negligible for periods greater than about 8 seconds. An example plot of these relationships is shown in figure 3.

Datawell now provides an improved modulator circuit in new Waveriders to eliminate the downward drift in sensitivity. This circuit can be installed in other Waveriders to bring the sensitivity back to specification and eliminate downward drift.

Figure 3.—Waverider 66967 Predeployment Calibration, 8/1/80.

In addition, corrections for the effect of changes in buoy (accelerometer fluid) temperature on buoy sensitivity must be applied. The accelerometers were designed to have minimum effect from temperature fluctuations but increases in the fluid electrical conductivity have shifted the temperature effects from the design condition. Datawell has provided general temperature-compensation curves (Ribe, 1981, Appendix, figure 1) which were adapted to provide a sensitivity-correction table (table 1) based on the ARSLOE pre and post-deployment calibrations.

Table 1. Representative Section of the Temperature Compensation Table.

Sensitivity at 22.4°C.	Increment to Add to Calibration Sensitivity.			
	22.4°C	16°	12°	8°
1.00	0	.001	0	-.002
.98	0	.014	.018	.020
.96	0	.016	.023	.029
.94	0	.015	.025	.034
.92	0	.017	.029	.039
.90	0	.024	.037	.049

The table is based on the assumption that the temperature of the fluid in the accelerometer is the same as the water temperature at the ARSLOE site. The water temperature at ARSLOE varied approximately linearly from 22.4°C. on Oct. 1, 1980 to 10.2°C. on Nov. 30, 1980.

4. Correction Tables

Tables have been provided in Ribe, 1981 which allow correction of the Waverider wave measurements during ARSLOE, both for the true, calibrated sensitivity at room temperature and for water temperature less than calibration temperature. In practice, pre and post deployment calibrations were close enough to being equal that the calibration closest to wave measurement date can be used to correct the wave measurements. Then two approaches are possible.

First approach would be to apply the tables to correct the component waves amplitude or variance spectra coefficient at corresponding period or frequency.

Second approach would be to apply both the Datawell relationship equation (1) and second order equation for deviation (δ) from this

relationship to amplitude or variance spectra coefficients in the appropriate manner, as described in this reference.

Either of these correction techniques will provide a buoy sensitivity for the Waverider electronics at 22.4°C. estimated to be within one percent of correct sensitivity. The buoy sensitivities are then corrected for the difference between the water temperature and 22.4°C.

References

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