Sea Trial of the New Datawell GPS Directional Waverider

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Abstract - Results of the first independent sea trial of the new Datawell GPS systems are presented. Measurements were conducted using a standard Directional Waverider buoy fitted with the new GPS sensors and the traditional accelerometers. This enabled a rigorous comparison with the tried and tested Directional Waverider. The new GPS system performed excellently, giving essentially the same results as the accelerometer sensors. The relative advantages of each measurement system are assessed.

I. Introduction

The Datawell Directional Waverider buoy represents the industry standard for directional wave measurement and has been used extensively by Fugro GEOS for over a decade. The buoy measures horizontal and vertical wave motion using accelerometer sensors. Datawell have recently developed a new system that uses Global Positioning System (GPS) signals to measure directional wave parameters. Fugro GEOS conducted the first independent sea trial of the new GPS system on behalf of Shell Global Solutions. The GPS sensors were installed within a standard Directional Waverider to allow a rigorous comparison of the results. Measurements started in July 2002 off the eastern Pacific coast and were ongoing at the time this paper was prepared. Simultaneous measurements were also made using an RDI Workhorse with Waves but these are described elsewhere [1].

II. GPS Wave Measurement Principle

The GPS system calculates the velocity of the buoy from changes in the frequency of GPS signals according to the Doppler principle. For example, if the buoy is moving towards the satellite the frequency of the signal is increased, and vice-versa. The velocities are integrated through time to determine buoy displacement. The measurement principle is illustrated in Fig. 1, which shows a satellite directly overhead and a satellite at the horizon. In practice the GPS system uses signals from multiple satellites to determine three-dimensional buoy motion.

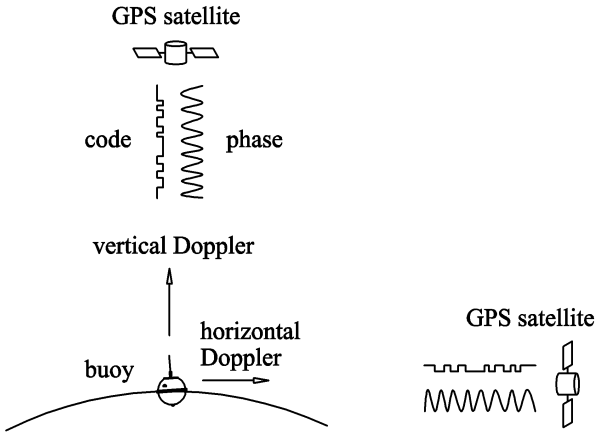

Fig. 1. The GPS wave measurement principle.

III. DATA PROCESSING AND COMPARISON

GPS and accelerometer data were recorded continuously at a rate of 2Hz throughout deployment. Large volumes of data were recovered during monthly service visits and processed using a combination of software provided by Datawell and developed in-house by Fugro GEOS. The Rijkswaterstaat SWAP program was used to calculate basic wave parameters every 20 minutes. The results from two months of measurement are compared in Fig. 2 to Fig. 4. Wave directions indicate the direction from which the waves arrived.

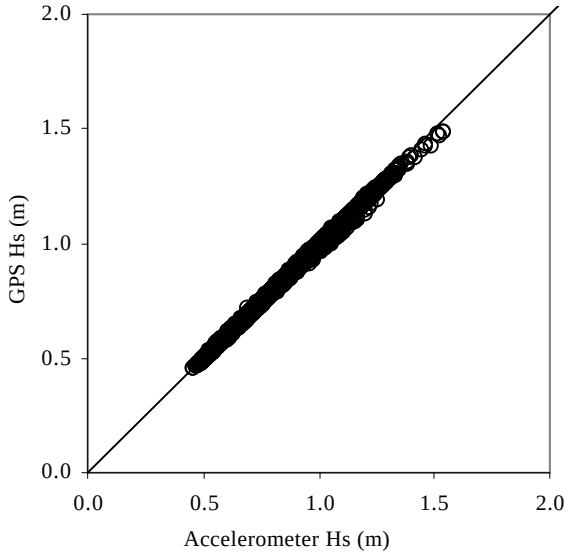

Fig. 2. Comparison of Significant Wave Height

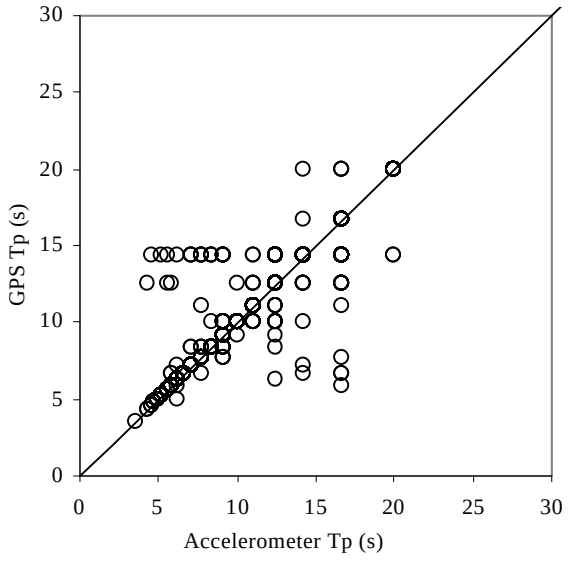

Fig. 3. Comparison of Peak Wave Period

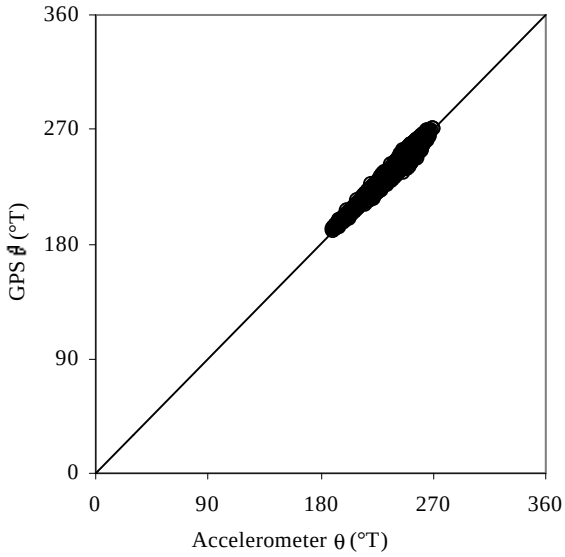

Fig. 4. Comparison of Mean Wave Direction

The wave period comparison in Fig. 3 does not appear favorable. There are a limited number of possible Tp values, determined by the 5mHz spectral resolution, so it is impossible to tell how many observations each circle corresponds to. The number of occurrences for each pair of Tp values is therefore given in Table I. This clearly shows that most of the observations agree and that significant differences were relatively rare. These differences are due to the presence of multiple peaks in the spectra, associated with separate wind-sea and swell components. Tp can only represent the single largest peak in the spectra, and on occasions when two peaks were of approximately equal magnitude, very small differences between the accelerometer and GPS spectra led to very different values of Tp.

IV. CONCLUSIONS

The new GPS system performed excellently in the field, producing virtually identical results to the tried and tested accelerometer sensors. Incorporation of both measurement systems into the same buoy has allowed a rigorous trial to be conducted. The new GPS buoy has several advantages over the traditional accelerometer based buoy. Firstly, the GPS system is theoretically capable of measuring waves with periods up to 100 seconds. Such long period waves can cause critical responses in large vessels even if the wave height is relatively low. In contrast, the traditional accelerometer based buoys cannot measure waves with periods longer than about 30 seconds. The long period wave data from the study described here are still under detailed investigation. At the time of writing this paper, it is not clear whether long period waves at the measurement location are large enough to be measured reliably using the GPS system.

TABLE I
NUMBER OF OCCURRENCES OF PEAK WAVE PERIOD (Tp)

GPS Tp	Accelerometer Tp (s)										
(s)	0-2	2-4	4-6	6-8	8-10	10-12	12-14	14-16	16-18	18-20	20-22
20-22								1	3		59
18-20											
16-18								1	543		
14-16			3	8	9	2	37	1407	46		2
12-14			3			4	825	4	8		
10-12				1	14	471	12	1	1		
8-10				5	249	1	2				
6-8			2	291	3		1	2	3		
4-6			118	2					1		
2-4		1									
0-2											

The GPS buoys should also be more robust than the traditional accelerometer buoys, which can be easily damaged by rough handling. The GPS system should also be cheaper and future versions may be more compact with a diameter of just 40cm.

The GPS system also has certain disadvantages. The performance of the new GPS buoy may be compromised in high sea states when receipt of the GPS signal can be interrupted. The most recently recovered data show that the GPS system remains operational in wave heights up to at least 2.5m. The capability of the system will be further tested as the measurements continue throughout the winter. The system will cease to function if GPS Selective Acquisition is activated, which may occur during a period of war. It is therefore unlikely that the GPS system will supercede the traditional buoy for all applications.

V. ACKNOWLEDGEMENTS

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VI. REFERENCES

[1] Jeans, G., Primrose, C., Descusse, N., Strong, B. and van Weert, P. (2002). A Comparison Between Directional Wave Measurements from the RDI Workhorse with Waves and the Datawell Directional Waverider. IEEE Seventh Working Conference on Current Measurement Technology, San Diego, CA, USA.