



DWR4 with ACM

Datawell - Oceanographic Instruments

The Directional Waverider that integrates wave and current measurements



DWR Wave measurements: same sensor, new data processing

The wave sensor of the Directional Waverider equipped with the Acoustic Current Meter option (DWR4/ACM for short) is identical to the sensor in the well-known Directional Waverider MkI, II and III. Processing of the measured data is now performed at the doubled sample frequency of 2.56 Hz. The high frequency limit of the heave and direction signals is shifted from 0.58 to 1.0 Hz. With this choice, the high frequency limit of the wave buoy is determined by the hydrodynamic response of the hull, not by the onboard instrumentation.

In addition, the DWR4 transmission protocol allows for a superior heave and horizontal displacement resolution. Easy comparison of the new DWR4 output to the familiar DWR-MkIII results is facilitated in the accompanying waves4 software suite.

Operational improvements

Extra features of the DWR4 compared to the DWR-MkIII to facilitate operation are:

- For identification, the buoy is tagged with an electronic ID-number (or actually two ID's for hull and hatch cover separately) which is transmitted along the measured data.
- As a kind of health parameters, the temperature of the Hippy-40 sensor as well as that of the hatch cover electronics are measured.
- For better energy management, the energy used from the batteries and the energy supplied by the optional solar panel are measured.

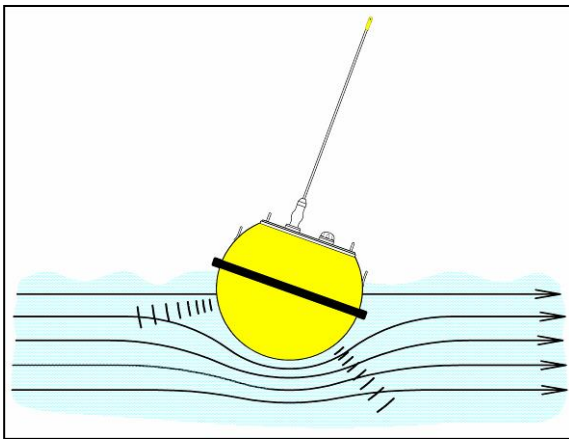


DWR4 with ACM

Datawell - Oceanographic Instruments

The Acoustic Current Meter

The DWR4 is extended with a surface current meter. This Acoustic Current Meter, or ACM for short, combines a robust measuring principle, Doppler shift, with a mechanical design that avoids vulnerability. This results in a coherent oceanographic instrument that meets the challenges at sea.



By integrating three acoustic transducers in the hull of the well-known Directional Waverider, the surface water velocity can be measured. The current is determined at roughly one metre below sea level, by measuring the Doppler shift of reflected 2 MHz pings. This robust and reliable method accords well with the Hippy 40 wave sensor, the standard in wave direction measurements.

Every 10 minutes, the magnitude and direction of the surface current are measured by three acoustic transducers. The transducers all face 30° down and are 120° laterally apart. Each transducer measures the projection of the current velocity along its axis. By time-gating the sensitive distance for the water velocity measurement is between 0.5 and 1.75 m from the hull. The current flow is affected by the presence of the Directional Waverider; close to the hull, the radial component of the velocity will be small, as opposed to the tangential components. Potential

theory predicts thus an underestimation of a few percent. No compensation for this effect is applied.

The velocities as measured by the transducers are converted into a North-West-Vertical water velocity by means of the pitch-roll sensor and the compass of the DWR.

During one minute each transducer fires 150 acoustic pings. The velocity measurements are quality-controlled and averaged.

Impact of waves on the current measurement

Due to the orbital nature of the wave motion, the horizontal velocity is not a constant over time and place. Different ranges of wave periods have a different impact on the water velocity measurement. Short waves, up to 1 second (1.5 m wavelength) average out in the volume over which the velocity is measured. Due to the size of the DWR, the wavelength is too small to make the buoy follow the waves and introduce artificial water velocity.

Waves which have a period smaller than 30 seconds (wavelength smaller than 1.5 km), can affect the velocity measured by the individual pings. Being moored flexibly, the Waverider buoy is able to follow the wave motion, which reduces the impact by the horizontal wave velocity significantly.

Wave periods beyond 30 seconds (wavelength longer than 1.5 km) will affect the individual water velocity measurement in the case of a moored buoy.

Impact of tidal motion on the current measurement

At the change of tide, the direction of the current typically changes by some 180° and the buoy traverses from one stationary position to the other. During the crossing, the actual water velocity is the vector-sum of the current as measured by the buoy



DWR4 with ACM

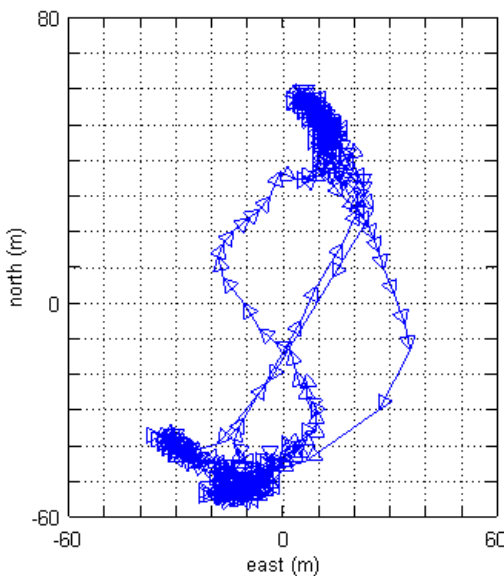
Datawell - Oceanographic Instruments

plus the velocity of the buoy itself. The velocity of the buoy when moving from one location to the other is typically small, up to a couple of centimetres per second, depending on the location and the mooring line length. At some locations however, the buoy velocity can be one or more decimetres per second at every change of tide.

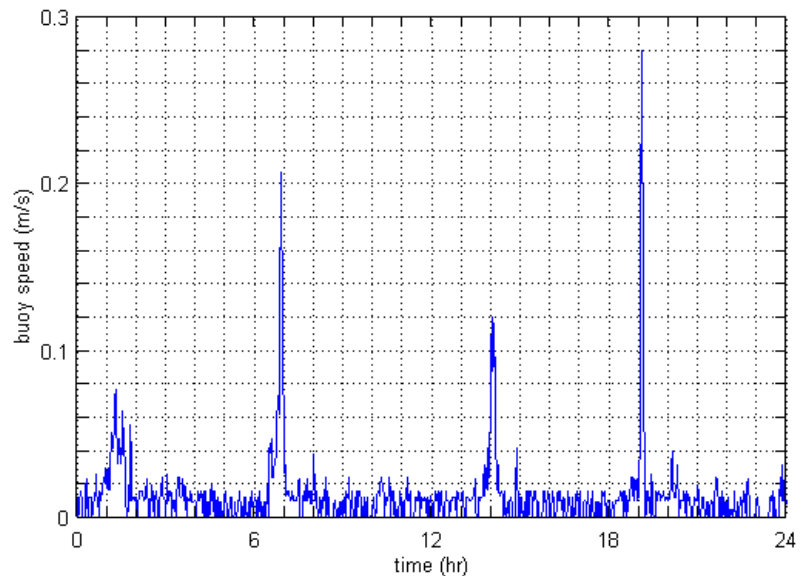
By measuring the position of the buoy by means of GPS every 2 minutes the buoy velocity is obtained. Each GPS-location is validated and results in a calculated buoy velocity that is transmitted alongside the velocity by the acoustic transducers.

Operational performance

During the development of the ACM option, several field tests have been performed off the coast near IJmuiden, The Netherlands, where a pole mounted ADCP provided reference data. Significant wave height during the test period rose to 4.5 m. Water velocity oscillated with the tides between 1 m/s to the south and 1 m/s to the north. Agreement with the ADCP is typically within 2 % and 0.02 m/s.



GPS buoy positions during a field test in 14 m deep water off the Dutch coast, near IJmuiden. Two clusters of points can be discerned, corresponding with flood tide (North) and ebb tide (South).

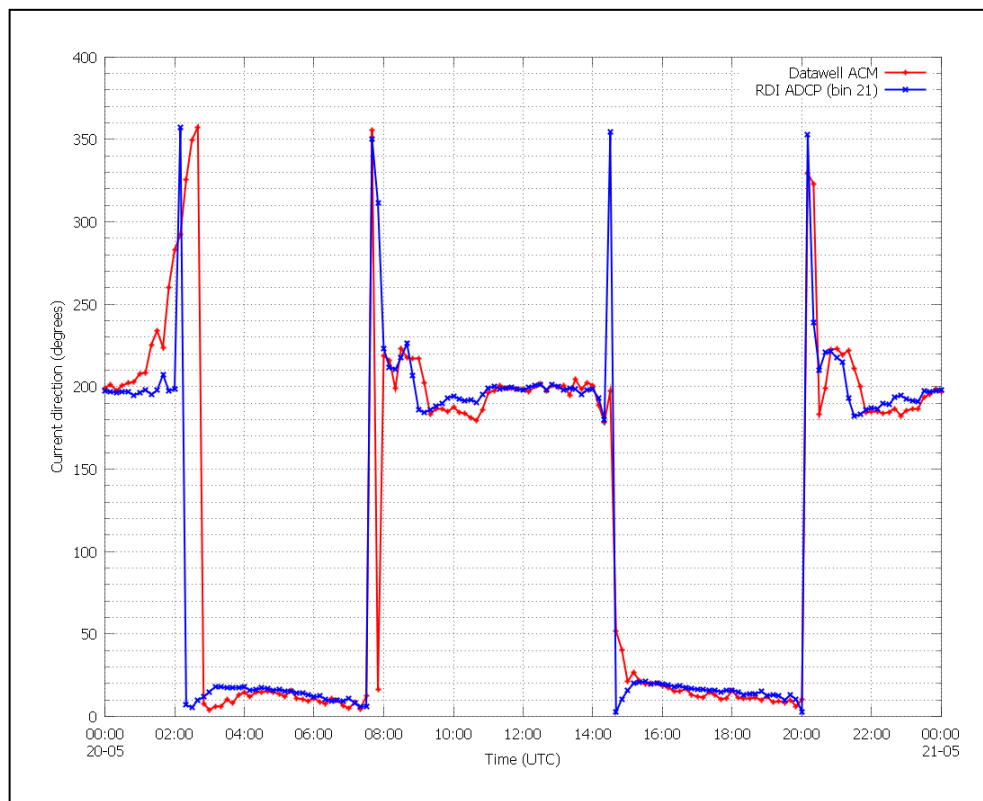
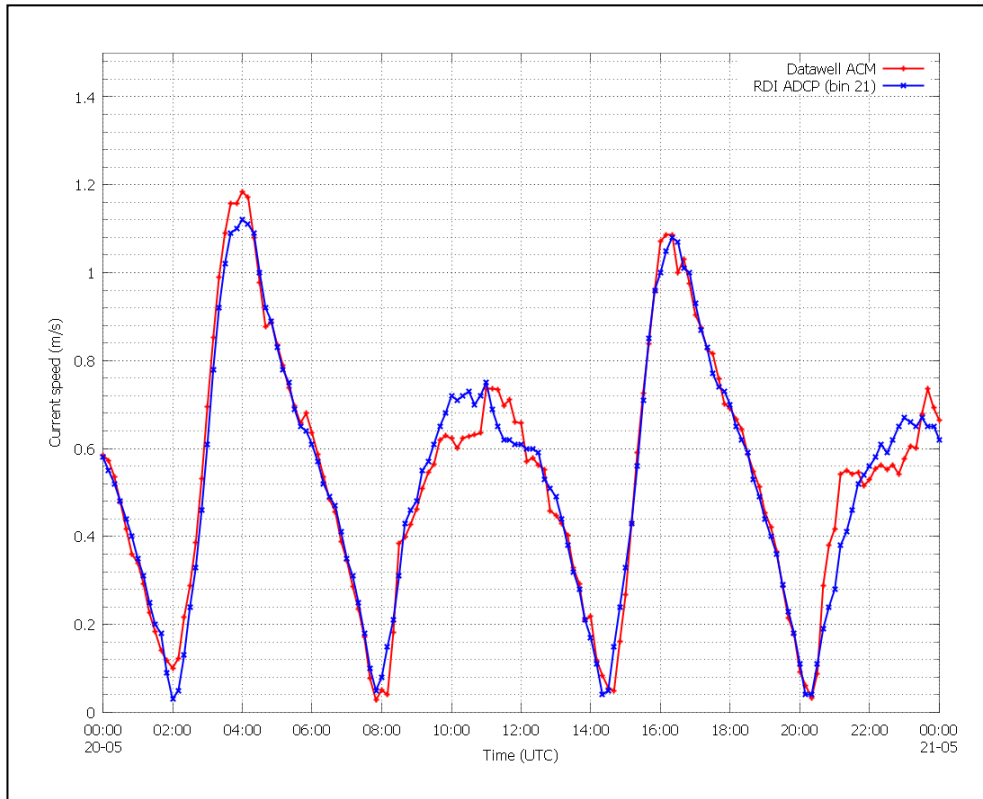


Buoy speed during field test



DWR4 with ACM

Datawell - Oceanographic Instruments





DWR4 with ACM

Datawell - Oceanographic Instruments

Fouling

The main reason for low signal to noise ratio of the received acoustic signal is fouling. In order to monitor the performance of the ACM, the RSSI of each transducer is determined and transmitted ashore.



Fouling after fourteen weeks at sea.

To reduce fouling on the hull, the user can apply an antifouling coating. This does not affect the quality of the current measurement. Care should be taken that the used antifouling does not interfere with the active surface which is made of epoxy.



Transducer hardly visible, still measuring.

Alternatively we offer a Cunifer10 hull to prevent fouling.

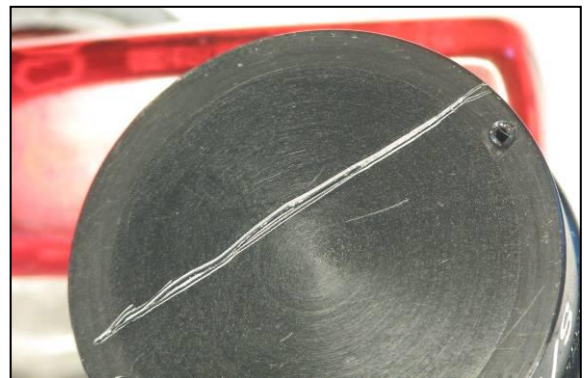
Transducer damage

The basis of the ACM are the well proven acoustic sensors made by Reson. Their intrinsic robustness is ruggedized by placing them in recess in a stainless steel housing. Should the surface of the transducer yet get damaged, this does not inevitably lead to failure of the current measurements. Even severe damage of the surface turns out to be acceptable.



Recessed transducer in the hull.

In the hostile environment of the sea, vessel interference cannot always be avoided. Collisions with ships or boats may leave a bump or a dent in the hull, which in turn may destroy the initial transducer alignment. A mechanical realignment of the transducers may be no easy job, or even impossible. In order to meet this situation, the azimuth and elevation directions of the transducers can be recalibrated. The new alignment matrix is stored in the ACM memory.



Severely damaged surface still measuring well. The scratch is 0.3 mm wide and 0.2 mm deep.



DWR4 with ACM

Datawell - Oceanographic Instruments

A perfectly floating buoy in water with a constant current profile, is not expected to measure vertical water velocity. A sudden change of measured vertical velocity may be indicative of a serious transducer misalignment, due to e.g. vessel interference, or of other incidents that necessitate service to the system.

Preparing the DWR with ACM

Prior to launching the DWR, some preparations are required. In case the hull needs to be sandblasted and/or painted, the acoustic transducers can be replaced by dummies to avoid damage. Three grey dummies are supplied with the buoy, as well as a special tool for removing and (re)mounting the transducers.

To protect the Hippy-40 sensor a triangle can be placed on the fender of the buoy.

Power switch

Switching off the power starts the procedure of closing and storing the current data file on the data logger. Data stored on the data logger is retained when the buoy is switched off or when the batteries are removed. The actual switch is covered by a small watertight dome that can be opened and closed with a standard 19 mm wrench, identical to the wrench for the standard Datawell 12 mm D-shackle in the mooring.



Air temperature

The CAT4 is a meteorological air temperature sensor integrated in the HF/flashlight antenna of the Directional Waverider. It consists of four individual sensors that have different radiative properties and will therefore measure different temperatures. The actual air temperature is derived from these different temperatures. Measuring height is 2 m above sea surface and the temperature range is -20°C - $+70^{\circ}\text{C}$.

Solar option

For extension of the operational life of the DWR4/ACM, a solar panel plus boostcaps can be installed. Solar energy will power the DWR4/ACM, in the 0.9m version the surplus energy is stored in boostcaps. When solar energy is not sufficiently available, energy is used from the boostcaps. When they are depleted, the primary batteries are used.



Communication

Iridium, Argos and GSM communication can help to retrieve a buoy that has broken from its mooring and can relay the measured wave and current data.



DWR4 with ACM

Datawell - Oceanographic Instruments

Operational issues

An eye-catching difference between the DWR4/ACM and its predecessors is the mooring eye no longer being placed “at the south pole”, on the axis of symmetry, but somewhat higher up, on the ‘meridian’ of one of the transducers. This symmetry breaking gives the spherical buoys for the first time a kind of ‘bow’ and ‘stern’. The asymmetric mooring eye limits the buoy’s average pitch, thus keeping the buoy

upright and the acoustic transducers underwater even in high current conditions.

In operation the DWR4 with ACM option is very similar to the DWR MkIII:

- The layout of the mooring line is identical.
- A triangle is strongly recommended in order to avoid damage to the Hippy40 sensor.
- The HF range is identical



DWR4 with ACM

Datawell - Oceanographic Instruments

Specifications

Current Meter	General	Method: Doppler Cell size: 0.4 m - 1.1 m from surface Update rate: every 10 minutes Sensors: three 2 MHz acoustic transducers
	Speed	Range: 0 - 3 m/s, resolution: 1 mm/s Accuracy: 1% of measured value +/- 2 cm/s Std. (1 σ): 1 - 3 cm/s (depending on wave height)
	Direction	Range: 0° - 360°, resolution 0.1° Accuracy: 0.4° - 2° (depending on latitude) typical 0.5° Reference: magnetic north
Wave sensor	Type and processing	Type: Datawell stabilized platform sensor Sampling: 8-channel, 14bit @ 5.12 Hz Data output rate: 2.56 Hz Processing: 32bits microprocessor system
	Heave	Range: -20 m - +20 m, resolution: variable, 1 mm smallest step Accuracy: < 0.5% of measured value after calibration < 1.0% of measured value after 3 year Period: 1.0 s - 30 s
	Direction	Range: 0° - 360°, resolution: 0.1° Heading error: 0.4° - 2° (depending on latitude) typical 0.5° Period: 1.0 s - 30 s (free floating) 1.0 s - 20 s (moored) Reference: magnetic north
Other	Water temperature	Range: -10 °C - +50 °C, resolution: 0.01 °C Sensor accuracy: 0.1 °C Measurement accuracy: 0.2 °C
	Integrated data logger	Compact flash module 1024Mb - 2048Mb
	LED Flashlight	Antenna with integrated LED flasher, colour yellow (590 nm), standard length 35 cm, "Standard pattern" 5 flashes every 20 s or "Increased pattern" 5 flashes every 15 s.
	GPS position	50 channel, update every 10 min, precision < 5 m
	Datawell HF link	Frequency range 25.5 - 35.5 MHz (35.5 - 45.0 MHz on request) Transmission range 50 Km over sea, user replaceable. For use with HVA compatible Datawell RX-C4 receiver.
General	Power consumption	522mW
	Batteries	0.7 m diam. operational life 11 months 0.9 m diam. operational life 23 months Type RC27B (270 Wh black)
	Material	Stainless steel AISI316 or Cunifer10
	Weight	Approx. 109 Kg 0.7m AISI316, 113 Kg 0.7m Cunifer10
		Approx. 192 Kg 0.9m AISI316, 201 Kg 0.9m Cunifer10
	Power switch	Data files are closed and secured
Hull painting	Brantho KorruX "3 in 1" paint system (no anti-fouling)	
Options	Air Temperature	Measuring height: 2 m above sea surface Temperature range: -20°C - +70°C Resolution: 0.01°C Exposed accuracy: $\pm 0.5^\circ\text{C}$ ($\pm 1^\circ\text{C}$ when solar induced error detected)
	Solar power system	Solar panel combined with Boostcaps capacitors (0.9m version only) Peak power: 5 W Capacity: 2WH
	Transmission	Iridium-SBD, Iridium-internet, GSM-internet and Argos
	Hull diameter	0.7m (excluding fender) 0.9m (excluding fender)