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Application Note
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Current and Wave Measurements from Autonomous Surface Platforms

Using Acoustic Doppler Current sensors from moving surface platforms are challenging. Constant changes in tilt and heading should be compensated for in every measurement. Magnetic disturbances from metal parts and acoustic reflections against objects below, e.g., the mooring line/chain, could introduce speed and directional errors. Another challenge is that acoustic broadband sensors become noisier if the buoy is "moving around" in the waves, figure 1.

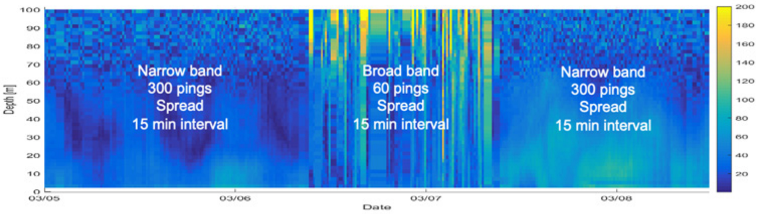

Fig 1: Broadband is unsuitable for current measurements from rocking platforms. Results come from a downward-facing sensor reporting in real-time. There was full two-way communication with the sensor, making switching between narrow and broadbands possible. Please note that data becomes noisier when broadband is activated and that the range of the sensor is about 70 m.

A 600 kHz, center frequency, Doppler Current Profiling Sensor (DCPS-600) was installed on an autonomous Sailbuoy that roamed the windy North Sea. The small (0.6 m long) vehicle was sailing in an area with oil platforms where several bottom-moored, fixed, up-ward looking Acoustic Doppler Current Profiling instruments (ADCPs) were installed. These data were compared with results produced by the downward-facing DCPS that was "pushed" around in the waves (Figure 2). Most of the time, the measurements agreed well. Still, when the significant wave height was above 6 m, the quality of the Sailbuoy-based current measurements were poorer, most likely because of air bubble intrusions from the waves below the hull. Two major factors for successful current measurements from a tiny platform like this are the use of a narrowband and the dynamic in-built movement compensation of the acoustic beams made in real-time and on the fly for every measurement. For more details about this and other comparative measurements with the DCPS on a Sailbuoy, see Wullenweber et al (2022).

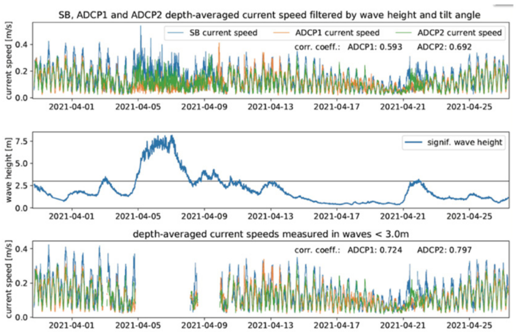

Fig 2: Depth averaged current speed filtered by wave height and tilt angle figure from Wullenweber et al (2022).

Wave measurements from dedicated wave buoys were compared with wave data from different types of "non-ideal" platforms like larger navigational buoys and wave-driven surface roaming platforms. The sensors used for the measurement were accelerometer-based Motus Directional Wave Sensors which have advanced mechanical and electronic noise reduction capabilities and inbuilt possibilities to compensate for the movements of non-ideal platforms.

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Experiments have been running for more than one year, figure 3, with wave heights from some cm up to 18 m and currents of up to 3 knots. The Motus sensor has its own inbuilt compass, but when used on magnetic platforms, external GPS compasses have been connected for directional compensation in real-time.

The Motus sensor calculates wave information internally on-the-fly, in the time and frequency domain, making it possible to send data in real-time efficiently. It can also output raw data. For more information on possible parameters, please see table 1.

More details about an extended evaluation of the Motus sensor on larger buoys and compared with dedicated wave measuring buoys are presented in Saetre et al. (2023).

References:

Saetre, C., Tholo, H., Hovdenes, J., Kocbach, J., Hageberg, A. A., Klepsvik, I. & Magnusson, A. K. (2023). Directional wave measurements from navigational buoys. Ocean Engineering, 268, 113161. https://doi.org/10.1016/j.oceaneng.2022.113161.

Wullenweber, N. Hole, L.R. Ghaffari, P. Graves, I. Tholo, H. Camus, L. SailBuoy Ocean Currents: Low-Cost Upper-Layer Ocean Current Measurements. Sensors 2022, 22, 5553. https://doi.org/10.3390/s22155553.

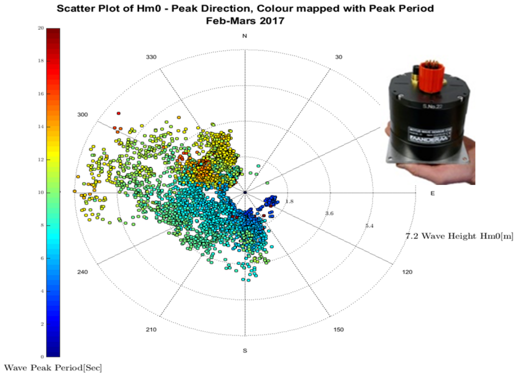

Fig 3: Examples of directional wave information, wave height (rings give scale), wave period (color), and direction. Data was collected for two months February-March 2017, off the west coast of Norway. Motus can distinguish between swell and wind-driven waves. Figure from Saetre et al (2023).d.

Frequency Based Parameters	
Significant Wave Height:	H_{mo}
Wave Height Swell/Wind:	H_{mo}
Peak Wave Direction Height:	θ
Peak Wave Direction Swell/Wind:	θ
First Order Spread:	σ
Mean Spreading Angle:	θ_k
Peak Wave Period:	T_p
Mean Wave Period:	T_{m02}
Long Crestedness Parameter:	τ
Mean Wave Direction:	θ_{avg}
Wave Energy Spectrum:	E(f)
Directional Wave Spectrum:	DWSm(f)
Principal Wave Directional Spectrum:	DWSp(f)
Orbital Ratio Spectrum:	K(f)
Fourier Coefficients Spectra:	A1(f), B1(f), A2(f), B2(f)
Time Based Parameters	
Significant Wave Height:	$H_{1/3}$, $H_{1/10}$
Mean Wave Period:	T_z, $T_{1/3}$, $T_{1/10}$
Maximum Wave Height:	H_{max}
Wave Period:	T_{max}
Wave Height Max Crest:	C_{max}
Wave Height Max Trough:	Tr_{max}
Heave Timeseries:	H(t)

Table 1: Onboard calculated parameters, frequency and time based, from the Motus sensor.

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