Woods Hole Oceanographic Institution

Upper Ocean Processes Group

Technical Note

Comparative Testing of Acoustic Doppler Velocimeter

To develop a better understanding of upper-ocean, mixed-layer dynamics, in-situ measurements are required to observe the velocity associated with coherent structures such as Langmuir cells. Historically, this type of observation has proved to be difficult since the expected horizontal and vertical velocities associated with transient mixed layer structures are small (less than 20 cm/s) when compared to the orbital velocities of the surface waves. Oceanic boundary layer measurements made from traditional propeller-type current meters suffer from flow distortion, large sample volume and slow response.

New acoustic remote sensing techniques offer the potential to overcome the limitations of propeller-type current meters. Here, we present results of a field test of the SonTek Acoustic Doppler Velocimeter (ADV) which uses an acoustic pulse to remotely measure the three components of water velocity at single point.

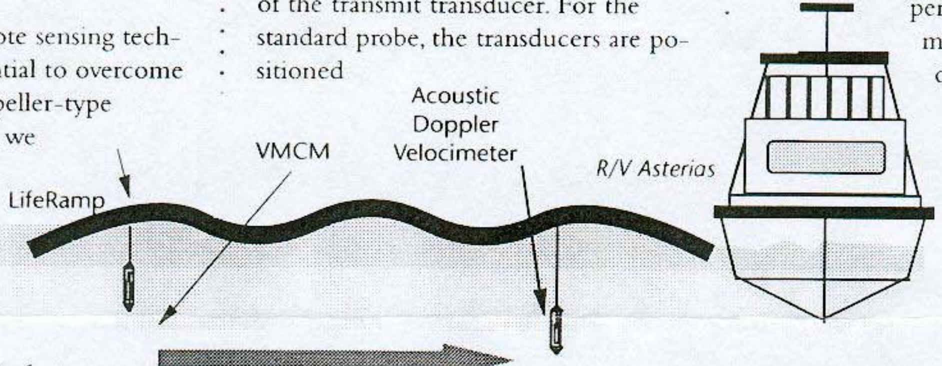

Fig. 1

A Vector Averaging Current Meter (VMCM) is used here as a standard for comparison comparison with the ADV. The VMCM is a propeller type current meter equipped with two rotors, a compass and a thermistor [1]. The VMCM recorded the data internally with an averaging interval of 7.5 seconds. The horizontal current is measured by counting the number of propellers turns in the given time interval. The VMCM records both the raw counts on each of the rotors and the vector averaged east and north components of the currents using the heading information from the compass. At this fast sample rate, the velocity resolution is only 1.25 cm s-1.

The Acoustic Doppler Velocimeter (ADV) has an acoustic frequency of 10 MHz, standard sampling frequency of 25 Hz and a sampling volume of less than a cubic centimeter [2,3,4]. The ADV sensor consists of four ultrasonic transducers, a transmit transducer located at the center of three receive transducers spaced at 120° azimuth intervals, and slanted 30° from the axis of the transmit transducer. For the standard probe, the transducers are positioned and oriented such that their acoustic beams all intercept at a common volume located about 50 mm in front of the transmit transducer. For field deployments, the position of the receive transducers can be extended such that the sampling volume is located 100 mm from the transmit transducer while the slant angle is preserved. The ADV was originally developed for laboratory work. For ocean deployment, the pressure case and probe were mounted in a VMCM cage to protect the instrumentation. There were no tilt or heading measurements made during the deployment, and instrument motion has not been removed from the data.

The VMCM and ADV were deployed beneath a LifeRamp which was tethered to the *R/V Asterias* in Buzzards Bay (Fig. 1). The LifeRamp is a floatation device developed for ice and water rescue. It consists of two pontoons, each approximately 30 mm in diameter and 15m long, separated by 1m. The ramp is stored in a roll and deployed by inflating. The LifeRamp is compliant with the ocean surface, yet provides plenty of buoyancy for both personnel and instrumentation and is easy to deploy. These features make it an attractive platform for deploying near surface instrumentation in a horizontal configuration for short term deployments.

The VMCM was placed outboard of the ADV. The VMCM and ADV sensing depths were approximately 1.0m and 2.0m respectively. For the first part of the deployment, the LifeRamp was positioned perpendicular to Asterias and tethered to the starboard side. The ADV was connected by cable to a ship board deck unit which provided data logging and power.

A total of 2 consecutive hours of 1 Hz data were collected from July 19 10:10 to 12:10. During the first hour, the winds were low and the ocean temperature held constant at 23.0°C.

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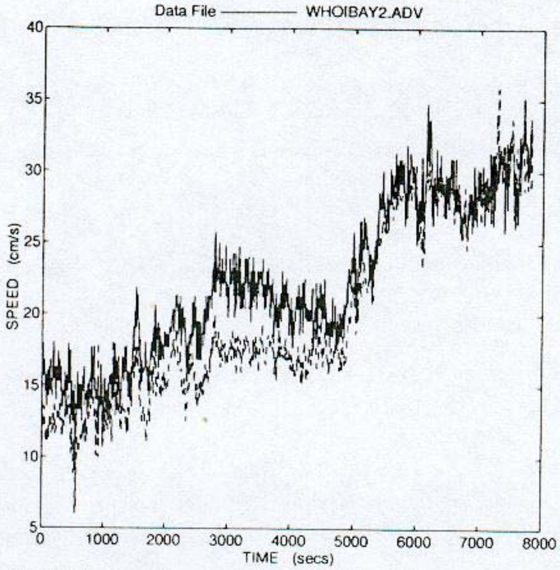

Fig. 2. Horizontal speed from ADV (solid) and VMCM (dashed) deployed in Buzzards Bay.

Then the winds picked up rapidly to over 5 ms^{-1} and the ocean temperature dropped steadily to 22.7°C.

The horizontal speeds from the ADV (smoothed over 8 seconds) and VMCM for these two hours are shown in Fig. 2. There is an offset between speeds from the two current meters during the first hour with the VMCM typically yielding speeds of 3-5 cm s-1 faster than the ADV. When the wind picks up and the temperature begins to drop, the two speed records converge. This suggests that there was some surface shear between 1m and 2m before the wind picked up. During a two hour time period, the speeds from the two current meters had a correlation coefficient of 0.955, a mean difference of 1.8 cm s-1 and a standard deviation of 2.12 cm s-1. Using just the last 50 minutes of the record, the mean difference drops to 0.04 cm s-1 with a standard deviation of 1.74 cm s-1.

For any long term near surface deployment, the in situ water temperature and salinity should be measured to update the sound velocity estimate used in the ADV processing. A 1°C temperature error leads to 0.2% error in the velocity estimate and with strong diurnal cycling of near surface temperatures this could lead to a measurable error.

The particulate matter in the ocean water provided plenty of acoustic backscatter signal from the sampling volume with no significant signal dropouts. The high sample rate, small sampling volume and low noise levels of the ADV allow for the resolution of upper ocean currents above 10 Hz if there is sufficient turbulent energy in the flow field.

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