Woods Hole Oceanographic Institution
Upper Ocean Processes Group

Technical Note

Nortek Aquadopp compass testing

March 2003

In optimal conditions, modern current meters are capable of measuring speed with an accuracy of about 1 cm/s [1]. However, directional uncertainty can result in component velocities with larger errors [1, 2]. For example, a 5° directional error in measuring a 35 cm/s eastward flow results in an erroneous southward component of 3 cm/s, even if the speed is measured perfectly. Thus, compass testing is routinely carried out as a part of the performance evaluation for current meters used by the Upper Ocean Processes Group.

In this note, we describe the results of compass tests done on Nortek Aquadopp current meters and profilers. These are acoustic backscatter sensors that determine current speed by detecting the Doppler shift of the "echo" from short acoustic pulses [3]. Using tilt and heading information, the along-beam velocities are converted into horizontal and vertical velocities on a pulse-by-pulse basis. By range-gating the return, the profiler produces a velocity profile from each pulse, whereas the current meter processes a single range gate.

Three Aquadopp compass tests were done in two different locations. Multiple instruments were evaluated in each test. The test procedure and results are described in more detail below.

Compass performance was examined using a rotating aluminum frame in a location relatively far (> 6 m) from potential magnetic field disturbances. The area surrounding the frame was surveyed with a handheld compass to ensure a stable magnetic field. The frame was aligned with magnetic north using a surveyor's compass. The north/south axis of the instrument was aligned with the frame by eye. The frame was then rotated through prescribed angles known to within about 0.5°, and the instrument compass reading recorded. The compass error was defined as the difference between the instrument heading and the frame heading.

The stability of the compass and frame during the test were evaluated by performing a counter-clockwise rotation immediately following the initial clockwise rotation. Differences in the zero offsets (compass error with the frame pointing north) were < 0.5° and RMS differences between the two rotations were about 0.8°.

The overall uncertainty associated with the test procedure was evaluated by repeated clockwise rotations of the same instrument, but with the test frame and instrument alignments reset between tests (in some cases by two different people). Zero offsets were within about 1°, and RMS differences were about 0.8°. In what follows, the overall uncertainty in the results is assumed to be +/- 1°.

The first set of compass tests was done during June of 2002 in Woods Hole, MA. These were new instruments at the time, with their "original" (uncalibrated) flux-gate compasses. The results of the compass tests are shown in Fig. 1. Our previous experience with a variety of instruments and compasses indicated that directional uncertainties of 2–3° are typical. Thus, the observed RMS errors of 2–7° and peak errors of up to 12° for the Nortek compasses were considered unacceptable.

Note that single-cycle curves (e.g., SN 333) indicate that offsets in the

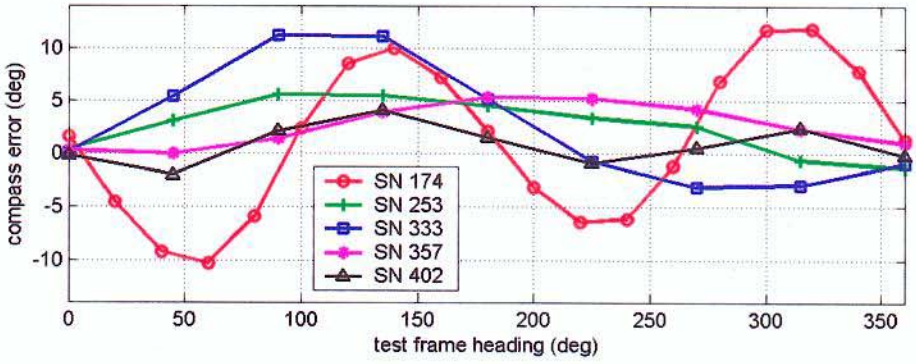

Figure 1. Results of June 2002 compass tests for four profilers (SN 253, 333, 357, and 402) and one current meter (SN 174). Note that in this case the profilers were aligned to force the compass to read zero when the test frame heading was zero.

horizontal axes of the magnetometer dominate the error, whereas double cycle curves (e.g., SN 174) indicate that gain errors dominate.

Following discussions with the manufacturer, the instruments were returned to the factory for a compass calibration that included correction for offsets and gains in the three axes of the flux-gate magnetometer. The second set of compass evaluations was done during November 2002 in Woods Hole, just after the factory calibrations had been applied. The results are shown in Fig. 2. The improvement in compass performance is notable. The RMS errors of 2.0–3.5 ° and peak errors generally < 4 ° are similar to results obtained from flux-gate compasses in other instruments. Note that while some offset errors are evident, gain errors appear to be largely eliminated.

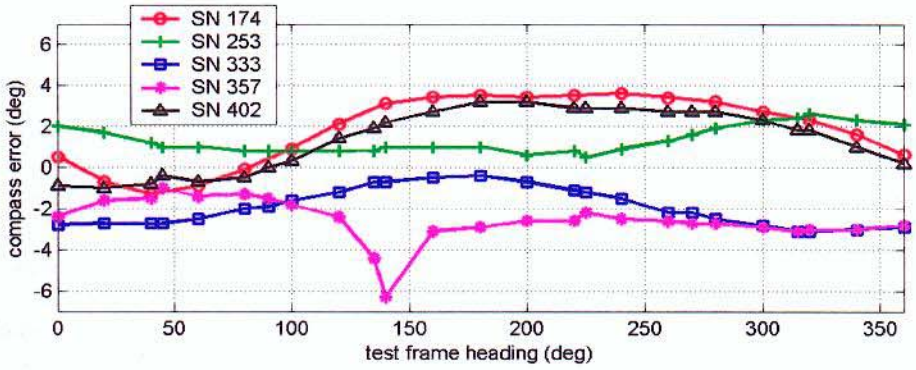

Figure 2. Results of November 2002 compass tests for four profilers and one current meter. Note that the vertical scale is 50% of that in Fig. 1.

It was of interest to determine whether the compass calibrations were "geographically stable", i.e., whether the results would vary at another location with different magnetic field strength. The opportunity arose to perform a third set of tests in Barbados during preparations for a mooring deployment cruise. The results of these tests are shown in Fig. 3. The RMS errors of 0.6–1.0 ° and peak errors of 1.2–2.2° are near the accuracy limits of the test procedure. It is speculated that the improved performance is due to the 40% increase of horizontal magnetic field strength in Barbados relative to Woods Hole.

Two developments since these tests were performed are notable. First, a "field calibration" option is now available so that the user can account for offset errors due to variations in the local magnetic field (e.g., due to the addition of a new battery). Second, a new compass, based on magneto-resistive sensors rather than the more common flux-gate magnetometers, is being developed [3]. It will be of interest to evaluate the performance of the new compass in light of the results presented here.

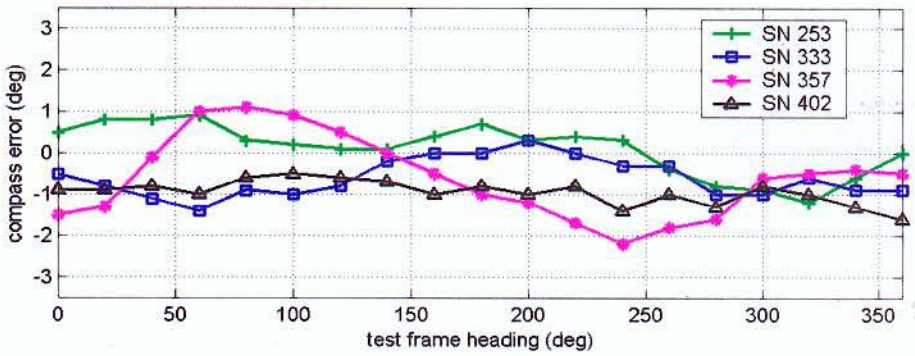

Figure 3. Results of February 2003 compass tests for four profilers (the current meter was not available for these tests). Note that the vertical scale is 50% of that in Fig. 2.

Acknowledgments

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References

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[2] Irish, J.D., A.J. Plueddemann and S.J. Lentz, 1995. In-situ comparisons of moored acoustic Doppler current meters, *Proc. IEEE Fifth Working Conf. Curr. Meas.*, 59-64.

[3] Further information is available at at http://www.nortekUSA.com.

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Note: Previous issues of UOP Technical Notes can be found on the web at http://uop.whoi.edu

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