Healy Underway 75-kHz ADCP System Data

Andreas Münchow, University of Delaware, muenchow@udel.edu

NSF Award ID 0125221

Feb.-28, 2007

Introduction

The USCGC Healy contains a 75-kHz phased-array ADCP (Ocean Surveyor) mounted under the hull to transmit and receive echos of acoustic pulses from which to estimate vertical profiles of horizontal currents. Attitude information such as heading, pitch, and roll is provided by an Ashtech ADU2-3DGPS receiver while position data is provided by a Trimble Centurion p-code DGPS system. These data streams provide earth-referenced absolute horizontal currents and their vertical variations from about 20-m below the surface to the bottom or about 400-m depth. Münchow et al. (2006) discuss the system, its performance in Arctic waters, and the removal of tidal currents in detail.

Data Processing and Screening

The ice-covered waters of our study area require a non-tradititional approach to remove data that are contaminated by ice, bubbles, or other sources of noise that bias our data. Traditional ADCP data processing averages individual pings into ensembles to reduce the large uncertainty associated with each individual acoustic ping. The implicit assumption of this approach is that the underlying propability density distribution of the acoustic data follows a Normal or Gaussian distribution, an assumption that is rarely tested. We performed a first test of this assumption by comparing the ensemble mean with the ensemble median velocity. For a Gaussian data distribution the mean and median are the same, however, we often find large discrepancies between these two statistics especially when the ship is operating in or near ice fields. This finding is little influenced by the standard, so-called error velocity data quality criteria that is commonly employed to reject data prior to the ensemble averaging as it is done by RDI data collection and processing software such as VmDas. Only a most restrictively small error velocity criteria removes all outliers along with most of the valid velocity data. Resolving this dilemma, we convert acoustic data along each of four beams for every ping into an earth-referenced velocity vector. Hence we apply heading, pitch, and roll information, calibration coefficients, as well the ship's absolute velocity vector over the ground for each individual ping prior to any averaging. Within each temporal averaging "ensemble" window, we sort these absolute, earth referenced velocity components from largest to smallest values. Assuming that the majority of the troublesome data lies at the extremes of the observed data ranges, we arbitrarily remove, say, the largest 10% and the smallest 10% of the data from the record. Hence our ensemble average consists of only 80% of the data in the middle of the observed velocity range. The removal of extreme values from the record effectively forces our data distribution towards a Normal distribution for which the standard deviation within each ensemble becomes a more meaningful statistic than one containing outliers.

We apply the same procedure to acoustic data returns from the bottom as well. These so-called bottom-tracking velocities are the most accurate way to measure the ship's movement over the ground which, in the absence of bottom-tracking, is generally provided by a navigational device such as the p-code, differential Global Position System (DGPS) aboard the USCGC Healy. As both the water- and bottom-tracking acoustics originate from the same sensor, the ship's velocity vector over the ground from navigational DGPS and from bottom-tracking ADCP estimates constitutes the basis for instrument calibration (Joyce, 1989). Histograms of the difference between DGPS and ADCP derived east and north velocity components describe discrepancies between these two systems at the velocity scale of interest in the range of ±0.2 m/s and reflect the combined inaccuracies of (a) the ADCP, (b) the attitude (heading, pitch, and roll), (c) the navigational GPS, and (d) a multitude of data processing software systems after we applied all calibrations and quality controls. Based on integrated histograms we claim that for a rather short 2-minute average 90% of our velocity vectors agree with each other to within better than 0.08 m/s or about 1% of the actual measurements. Since the histograms follow a Gaussian distribution rather closely, we further claim that a longer averaging interval in time or some additional averaging in space will further reduce this uncertainty as $1/\sqrt{N}$, where N are the degrees of freedom.

Data Format:

File format description for USGGC Healy 75-kHz ADCP Data
(output from osadcp4.f as of Nov.1, 2006):

A single header line contains in columns #1 through #15:

#1 Lines of data to follow
#2 Total number of profiles
#3 Temporal Ensemble averaging time (minutes)
#4 "Calibrations:"
#5 dummy
#6 Joyce (1986) alpha (misalignment)
#7 Joyce (1986) beta (scaling)
#8 vertical misalignment-1
#9 vertical misalignment-2
#10-15 File Creation Date string

Data are in columns 1 through 26:

#01 Year
#02 Month
#03 Day
#04 Hour UTC
#05 Minute UTC
#06 Longitude
#07 Latitude
#08 Bottom Depth (m)
#09 Bin Depth (m)
#10 Velocity East (cm/s)
#11 Velocity North (cm/s)

#12 Velocity Vertical (cm/s)
#13 Velocity Error (cm/s)
#14 Velocity Standard Deviation within averaging interval (cm/s)
#15 Percent-Good-Pings for water tracking pings
#16 Average Percent of 3-beam solutions within averaging interval
#17 Ship Velocity East Bottom-track (cm/s)
#18 Ship Velocity East GPS (cm/s)
#19 Ship Velocity North Bottom-track (cm/s)
#20 Ship Velocity North GPS (cm/s)

#21 Ship Velocity Vertical Bottom-track (cm/s)
#22 Reference (1-BT, 0-GPS)
#23 Percent-Good-Pings for bottom-tracking pings
#24 Sequential Bin Number (reverse order)
#25 Sequential Profile Number
#26 File Number or originating raw data file (.ENR,.ENS,.N1R,.N2R)

Andreas Muenchow, University of Delaware, Jan.-9, 2007

References:

Joyce, T.M, 1989: On in situ calibration of shipboard ADCPs. J. Atmos. Ocean. Tech., 6, 169-172.

Münchow, A., H. Melling, and K.K. Falkner (2006): An Observational Estimates of Volume and Freshwater Flux Leaving the Arctic Ocean Through Nares Strait. J. Phys. Oceanogr., 36, 2025-2041.
[http://newark.cms.udel.edu/~muenchow/papers/Nares_JPO2005.pdf]

Web-sites and Data Access

http://newark.cms.udel.edu/~muenchow/cgi/form2.cgi