Cruise Report: LADCP data from CLIVAR PO2W 2013

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Personnel

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System description

The University of Hawaii (UH) ADCP group used a Teledyne/RDI Workhorse 150 kHz Lowered Acoustic Doppler Current Profiler (LADCP) to measure ocean currents during the spring 2013 CLIVAR/Carbon P02 cruise from Yokohama, Japan to Honolulu, Hawaii. The instrument was held near the base of the rosette by an anodized aluminum collar connected to three struts that were in turn bolted to the rosette frame. Secondary restraint was provided by a ratchet strap tightened around the instrument and tied to an upper strut of the frame. Power for the LADCP was provided by a 48 V Deep Sea Power and Light sealed oil-filled marine battery. It was fastened with cord to the rosette frame.

Between casts, a single power/communications cable connected the LADCP and battery to a computer and a DC power supply to initialize the LADCP, collect data after casts, and recharge the battery. Communication with the instrument was managed by a custom serial custom communication package.

Operating parameters

The LADCP used nominal 16 m pulses and 8 m receive intervals (assuming a standard $1500\,\mathrm{m\,s^{-1}}$ speed of sound). The blanking interval (distance to first usable data) was 16 m.

A staggered pinging pattern was used, with alternating 1.2 s and 1.6 s periods between pings. This was to avoid a problem referred to as Ping-to-Ping Interference (PPI), which happens when a strong echo off the bottom from a previous ping overwhelms the weak scattering signal from the water column. PPI occurs at a distance above the ocean floor of $\Delta z = \Delta t \cdot c/2$ where Δt is the period between pings and c is the speed of sound. With constant ping rates, the artifact hits a single depth, essentially invalidating all data at that depth. By alternating delays, we lose half the data at two depths, but have some data through the entire column.

The LADCP control file

```
CR1    # factory defaults
PS0    # Print system serial number and other info.
WM15   # sets LADCP mode; WB -> 1, WP -> 001, TP -> 000100, TE -> 00000100
TC2    # 2 ensembles per burst
TB 00:00:02.80     ### also try old BB settings, 2.6 and 1.0
TE 00:00:01.20
TP 00:00.00
WN40    # 40 cells, so blank + 320 m with 8-m cells
WS0800  # 8-m cells
WT1600  # 16-m pulse
WF1600  # Blank, 16-m
WV330      # 330 is max effective ambiguity velocity for WB1
EZ0011101  # Soundspeed from EC (default, 1500)
EX00100    # No transformation (middle 1 means tilts would be used otherwise)
CF11101    # automatic binary, no serial
LZ30,230   # for LADCP mode BT; slightly increased 220->230 from Dan Torres
CL0        # don't sleep between pings (CL0 required for software break)
```

Data processing

Data were processed using version IX.8 of Andreas Thurnherr's implementation of Martin Visbeck's LADCP inversion method, developed at the Lamont-Doherty Earth Observatory of Columbia University. The LDEO code is written in Matlab, and performs a long chain of calculations, including transforming the raw LADCP data to Earth coordinates; editing out suspect data; meshing with CTD data from the cast and simultaneous shipboard ADCP and GPS data; then running both an inverse method and a shear-based algorithm to obtain ocean currents throughout the profile. The shear-based calculation is used as a check on the inverse method–if they agree, confidence in the solution is enhanced.

Only preliminary data processing was performed during the cruise; full processing takes more time than was available. The automatic data editing is not completely adequate, as ocean bottom reflections are not always edited out and the algorithms for detecting and discarding PPI require more work.

Data gathered

Data were successfully obtained in every cast at each station. Since the LADCP operated independently from the CTD data system, it was not affected by the noise problems that bedeviled the first 14 stations. Preliminary vertical profile plots of each station were made available on the ship's website within 12 hours of each cast.

Problems encountered

We had no major hardware or software problems during the cruise, but there were a few glitches. The ADCP twice slipped down in its collar and had to be lifted up and re-secured. We also experienced an odd noise problem. One of the beams (#4) appeared to be getting weak, with decreased signal:noise and reduced range. After some email discussion, Eric Firing opined that it was more likely an acoustic or electronic interference problem than a failing transducer. This was confirmed when we rotated the instrument 90°. The suspect beam improved while its neighbor (#2) deteriorated. There was a net improvement, however, so we left the LADCP in its new position.

It is possible that the 120 kHz altimeter caused acoustic interference, but exactly the same altimeter and rosette were used during the CLIVAR A20/A22 cruises without the same symptoms. Another possibility is that some instrument on the rosette or along the cable introduced electrical noise. Noise from the winch caused major problems with the CTD system, but that was fixed with no obvious change in beam 4 performance. The secondary O_2 sensor is grounded to the rosette, so could perhaps be at fault, but the beam weakness was visible in the data before that sensor was installed. We have not really resolved the problem, but are satified that the effects on the data are small.

Sample data plots

We made both vertical profiles of individual plots and contour plots along the cruise track available on the ship's network. A contour plot of data from the entire cruise may be the best capsule summary of the preliminary data. The Kuroshio current, with a maximum speed of about $1.2\,\mathrm{m\,s^{-1}}$ is at the far left of Figure 1, together with a countercurrent, presumably an eddy, immediately to the east. Currents through the rest of the basin are much weaker, fading to the east. There are often local maxima between 3 and 5 km, and currents near the bottom frequently exceed $10\,\mathrm{cm\,s^{-1}}$.

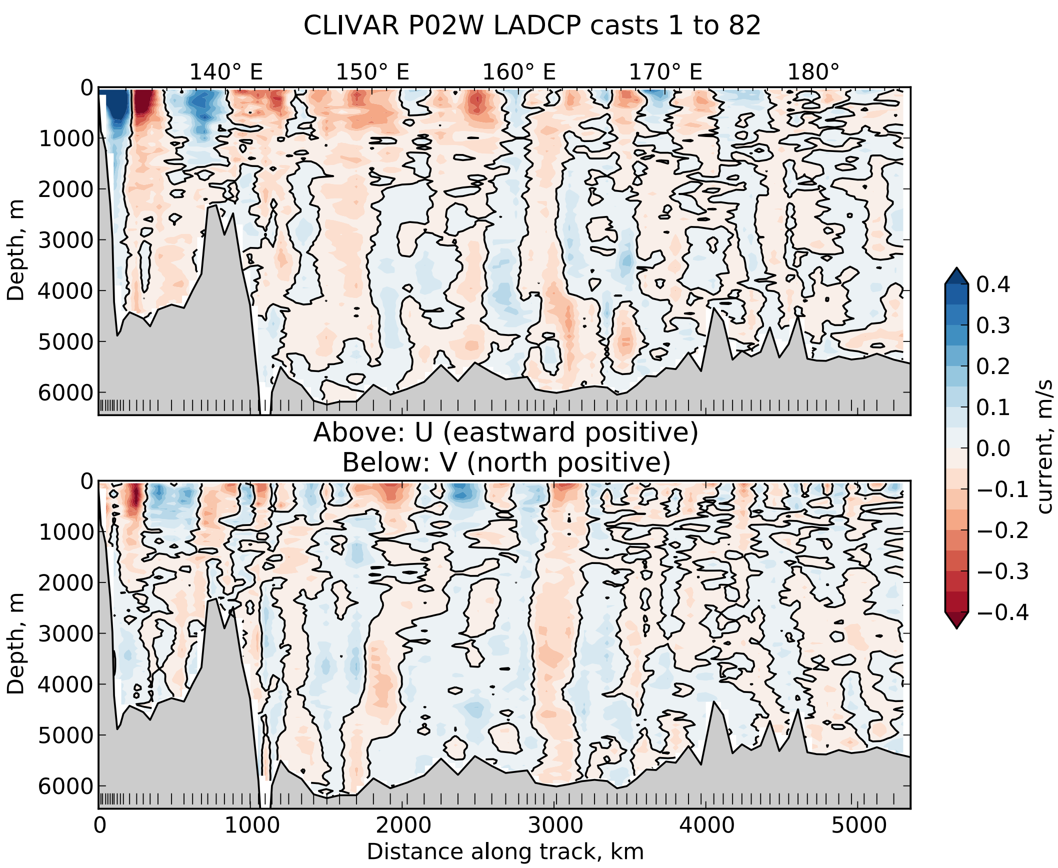

Figure 1: Contour plot of P02W stations 1 to 82. Tick marks along the bottom of each plot are station locations.

Acknowledgements Many thanks are due to Jim Swift for leading the science effort with equanimity in the face of some rather difficult problems at the start of the cruise. Robert Palomares actually mounted the LADCP in the rosette and made sure it was safe. Mary Johnson and Frank Delahoyde made the CTD data available so quickly and easily that I hardly had to think about it.

More thanks to the entire crew and science complement of the *Melville*, who were unfailingly helpful and made the ship a clean and pleasant place to work. They strove hard, and successfully, to cope with the hardware breakdowns the plagued the first weeks of the cruise. The cooks, Mark and Jeremy, not only made good food, but in such variety that I often marveled at their inventiveness.